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UNITED STATES

DEPARTMENT OF THE INTERIOR

FINAL
ENVIRONMENTAL STATEMENT
Volume 4 of 5

Proposed
1975 OUTER CONTINENTAL SHELF OIL AND GAS GENERAL LEASE SALE OFFSHORE SOUTHERN CALIFORNIA

(O.C.S. Sale No. 35)

Prepared by the

BUREAU OF LAND MANAGEMENT

Curt Berklund

Director

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TABLE OF CONTENTS FOR APPENDIX

1) FEDERAL REGISTER: POTENTIAL FUTURE OUTER CONTINENTAL SHELF OIL AND GAS LEASING: REQUEST FOR COMMENTS 1

2) FEDERAL REGISTER: OUTER CONTINENTAL SHELF, POTENTIAL FUTURE OIL AND GAS LEASING: PREPARATION OF ENVIRONMENTAL IMPACT STATEMENT 4

3) PROPOSED SCHEDULE PROVISIONAL OCS LEASING 8

4) DESCRIPTION OF OFFSHORE SOUTHERN CALIFORNIA OIL AND GAS TRACTS SELECTED FOR ENVIRONMENTAL STUDY 11

5) OCS OPERATING ORDERS, NOS. 1 THROUGH 12; PACIFIC AREA 20

6) NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES ON THE OUTER CONTINENTAL SHELF, PACIFIC REGION 89

7) SAMPLE OUTER CONTINENTAL SHELF LEASE FORM 104

8) A DESCRIPTION OF OIL AND GAS OPERATIONS 109

9) HISTORY OF DRILLING AND OFFSHORE OIL AND GAS OPERATIONS 228

10) DESCRIPTION OF THE ENVIRONMENT 275
   - A. GEOLOGY 276
      - 1. Stratigraphy and General Geology 277
      - 2. Description of Major Geomorphic & Bathymetric Features 289
      - 3. The Shallow Continental Shelf and its Sediments 299
      - 4. Faults and Folds 394
      - 5. Geologic Hazards 310
      - References 337

   - B. CLIMATE 344
      - References 347

   - C. PHYSICAL OCEANOGRAPHY 348
      - 1. Water Temperature 349
      - 2. Ocean Wind Waves 350
      - References 369

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D. CHEMICAL OCEANOGRAPHY 372
References 373

E. BIOLOGICAL OCEANOGRAPHY 374
1. Phytoplankton 375
2. Zooplankton 381
3. Benthos 390
4. Nekton 398
5. Marine and Shore Birds 427
References 458

F. IMPORTANT MARINE ASSOCIATED HABITATS 503
1. Marshes, Bays, and Estuaries 504
3. Channel Islands 522
4. Mainland Terrestrial Biomes 533
References 539

G. HUMAN UTILIZATION 553
2. Ocean Dumping and Military Use 553
3. Recreation and Allied Resources 559
5. Commercial Biological Resources 578
References 618

H. ENVIRONMENTAL PROBLEMS 624
2. Past and Potential Sources of Water Quality Degradation 624
References 625

I. HISTORICAL AND PROJECTED ECONOMIC GROWTH 626
References 627

11) SUMMARY OF U.S. COAST GUARD REGULATIONS CONCERNING OFFSHORE STRUCTURES AS HAZARDS TO NAVIGATION 629

12) GEOLOGIC TIME CHART 632

13) LIST OF SIGNIFICANT FELT EARTHQUAKES IN THE BORDERLAND REGION, 1800 to 1973 634

14) MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITIES 661

15) REPORT OF THE CALIFORNIA PARTY BOAT FLEET STATEWIDE 1972 663

16) POPULATION, EMPLOYMENT, PERSONAL INCOME AND EARNINGS BY INDUSTRY: HISTORICAL AND PROJECTED 1950-2020; INDEXES OF PRODUCTION FOR SELECTED INDUSTRIES, PROJECTED 1980-2020; BUREAU ON ECONOMIC ANALYSIS (BEA) CODE NUMBERS 308, 409, 445, 477, 481. 677

17) MATRIX TABLES 690

18) EFFECTS OF OIL ON MARINE ECOSYSTEMS 726
References

19) MEMORANDUM OF UNDERSTANDING BETWEEN BLM AND USGS FOR OCS PIPELINES 744

20) EXCERPT OF FIFTEEN RECOMMENDATIONS FROM A REPORT ISSUED BY A SPECIAL WORK GROUP OF THE USGS, MAY 1973, IN RESPONSE TO OCS SAFETY AND POLLUTION 749

21) REPORT OF THE WORK GROUP ON OCS SAFETY AND POLLUTION CONTROL, U.S. GEOLOGICAL SURVEY 760

22) AN EVALUATION OF "ENERGY UNDER THE OCEANS," A REPORT OF STUDY CONDUCTED BY THE TECHNOLOGY ASSESSMENT GROUP, SCIENCE AND PUBLIC POLICY PROGRAM, THE UNIVERSITY OF OKLAHOMA, AUGUST 1973 798

23) SUPPLEMENT TO REPORT OF THE WORK GROUP ON OCS SAFETY AND POLLUTION CONTROL 808

24) CALIFORNIA OIL SUPPLY AND DEMAND, 1973-1985 828

25) THE CALIFORNIA COASTAL ZONE CONSERVATION ACT OF 1972 830

26) CHARACTERISTICS OF INORGANIC METAL POLLUTANTS 841

27) AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM 866

APPENDIX 1

FEDERAL REGISTER: POTENTIAL FUTURE OUTER CONTINENTAL OIL AND GAS LEASING REQUEST FOR COMMENTS

Notices

This section of the FEDERAL REGISTER contains documents other than rules or proposed rules that are applicable to the public. Notices of hearings and investigations, committee meetings, agency decisions and rulings, delegations of authority, filing of petitions and applications and agency statements of organization and functions are examples of documents appearing in this section.

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

POTENTIAL FUTURE OUTER CONTINENTAL SHELF OIL AND GAS LEASING

Request for Comments

In order to implement President Nixon's directive to lease ten million acres in 1975, and in order to implement more fully the purposes and objectives of the Outer Continental Shelf Lands Act, all concerned parties representing the oil and gas industry and the general public are invited and encouraged to submit information concerning areas of interest for offshore oil and gas leasing and to identify problem areas. This is being done in order to help ensure that scarce resources for exploration and development can be employed on the most promising areas consistent with environmental safeguards. Regulations or procedures necessary to implement the other actions announced by the President in his Energy Message relating to Outer Continental Shelf (OCS) leasing will be subsequently published for public comment before they become effective and are not part of this request for comment.

Oil and gas resources of the continental margin, including those beyond the 200 meter depth contour, subject to jurisdiction of the United States are to be considered. Precise continental shelf boundaries between the U.S. and opposite or adjacent states have not, with some exceptions, been agreed. Accordingly certain areas are or may be subject to dispute. No decision has been made to undertake leasing in actually or potentially disputed areas while efforts are being made to reach agreement with the nations concerned. In this connection reference is made to the last sentence of Department of State Public Notice 320 appearing in 35 FR 3301 of February 20, 1970.

Leasing in the Cook Inlet of Alaska and on the Atlantic OCS is contingent on resolution of the litigation between the Federal Government and the State of Alaska and Atlantic coastal states regarding areas of jurisdiction or an alternative resolution of the issues. Further, the President's Council on Environmental Quality is conducting studies of the environmental impact of oil and gas production on the continental shelf of the Atlantic Ocean and the Gulf of Alaska. No leasing in these areas will be permitted unless it is determined that oil and gas exploration and development can proceed in an environmentally satisfactory manner. However, information concerning OCS areas of interest is being requested at this time in order to identify areas of special resource potential and of environmental value. It is the intention of the Department of Interior to conduct a call for tract nominations on more specific areas after consideration of the comments resulting from this request and, where appropriate, after resolution of State/Federal jurisdiction disputes and a determination from the CEQ Atlantic and Gulf of Alaska studies that development can proceed in those areas in an environmentally satisfactory manner. Information received in response to this request will also be considered in determining future leasing plans.

The areas to be commented on are as follows:

	Approximate location
Atlantic Coast OCS areas:	
1. North Atlantic	Bay of Fundy to Cape Code north of 40° N. latitude and south of.[1]
2. Mid-Atlantic	Cape Cod to Cape Hatteras between 40° N. to 35° N. latitude.
3. South Atlantic	Cape Hatteras to Key West south of 35° N. latitude.
Gulf of Mexico OCS areas:	
4. East Gulf	East of 88° W. longitude.
5. Central Gulf	Between 88° W. to 93° W. longitude.
6. West Gulf	West of 93° W. longitude to Mexican border.
Pacific OCS areas:	
7. Southern California Borderland	South of 34° N. latitude to Mexican border (except Santa Barbara Channel).
8. Santa Barbara	Santa Barbara Channel.
9. North and Central California	North of 34° N. latitude to California-Oregon border (except Santa Barbara Channel).
10. Washington-Oregon	Between California-Oregon border and Canadian border.
Alaska OCS areas:	
11. Cook Inlet	South of 60° N. latitude.
12. Southern Aleutian Shelf	West of 153° W. longitude.
13. Gulf of Alaska	North of 56° N. latitude, east of 153° W. longitude.
14. Bristol Bay	South of 58° N. latitude, east of 165° W. longitude.
15. Bering Sea Shelf	U.S. waters south of 66° N. latitude.
16. Beaufort Sea	Between 142° W. and 160° W. longitude.
17. Chukchi Sea	U.S. waters north of 66° N. latitude, west of 160° W. longitude.

[1] The line drawn from a point at: 42°19.9′ N. latitude, 67°46.9′ W. longitude, thence to 42°9.3′ N. latitude, 67°40.0′ W. longitude, thence 41°42.4′ N. latitude, 67°28.8′ W. longitude, and ending at 41°15.3′ N. latitude, 66°58.9′ W. longitude.

Other Areas of interest may be commented upon by appropriate area designation.

AREAS OF OIL AND GAS RESOURCE POTENTIAL

The following information is requested:

1. Rank by order of oil and gas potential the areas of interest listed above.

2. Outline of geologic structures of areas of interest shown on appropriate maps. All such information will remain confidential on request. Bureau of Land Management official leasing maps may be obtained from: (1) Gulf of Mexico Outer Continental Shelf Office, Suite 3200, The Plaza Tower, 1001 Howard Avenue, New Orleans, Louisiana 70113; (2) Pacific Outer Continental Shelf Office, 300 North Los Angeles Street, Los Angeles, California 90012; or, (3) Alaska Outer Continental Shelf Office, 121 W. Firewood Lane, Room 270, P.O. Box 1159, Anchorage, Alaska 99510.

3. For each area of interest, estimated time periods required to achieve initial and peak production after a discovery is made, and identification of specific factors that may constrain development for these areas.

AREAS OF ENVIRONMENTAL CONCERN

The following information is requested:

1. Rank with areas of greatest environmental concern first the above areas and indicate specific environmental values which exist and damages which might be incurred.

2. If possible, indicate the location on maps of specific environmental features or hazards to be considered in these areas if their resource potential is devel-

2

oped (locations where maps can be obtained listed above).

3. Indicate specific actions which may be taken to reduce or eliminate potential conflicts with oil and gas exploration and development activities.

The information should be submitted no later than May 1, 1974, in envelopes or packets marked "Request for Comments on Potential Future, Outer Continental Shelf Oil and Gas Leasing." The information should be submitted to Director, Attention 730, Bureau of Land Management, Washington, D.C. 20240. Copies of the information should also be sent to the Chief, Conservation Division, No. 600, U.S. Geological Survey, National Center, Reston, Virginia 22092.

George C. Turcott,
Associate Director,
Bureau of Land Management.

Approved: February 15, 1974.

John C. Whitaker,
Acting Secretary of the Interior.

[FR Doc.74-4126 Filed 2-15-74;4:51 pm]

[Wyoming 0310786]

WYOMING

Opening Land to Small Tract Application

February 11, 1974.

1. Pursuant to Small Tract Classification Wyoming 0310786 dated September 14, 1971, the following described land will be opened to small tract application as set out below, for sale under the Small Tract Act of June 1, 1938, as amended; 43 U.S.C. 682a–e (1970):

Sixth Principal Meridian, Wyoming

T. 40 N., R. 78 W.,
Sec. 30, lot 7.

The above described parcel contains 4.79 acres.

The land is located in Natrona County near Midwest, Wyoming. It is bordered on the east and south by U.S. Highway 87 and State Highway 387.

2. At 10 a.m. on February 21, 1974, the land will be open to applications to purchase the lot under the Small Tract Act. All valid applications received at or prior to 10 a.m. on February 21, 1974, will be considered as simultaneously filed at that time. All applications filed after that time will be considered in the order of filing.

3. Applicants must file, in duplicate, with the Chief, Lands and Mining Section, Bureau of Land Management, PO Box 1828, Cheyenne, Wyoming, application Form 2730-1 filled out in compliance with instructions on the form. The application must be accompanied by a relinquishment of the existing small tract lease W-0310786 embracing the land, conditioned upon conveyance of title. Copies of the application form can be secured from the above-named official. The application must be accompanied by a filing fee of $10 and the purchase money for the land in the amount of $29,000. Failure to transmit these payments with the application will render the application invalid. Advance purchase payments will be returned to unsuccessful applicants. All filing fees will be retained by the United States.

4. The patent (the title transfer document), when it issues, will contain a reservation of all minerals to the United States, and will be subject to rights-of-way of record and the rights of prior oil and gas permittees.

Daniel P. Baker,
State Director.

[FR Doc.74-3938 Filed 2-19-74;8:45 am]

National Park Service

CHESAPEAKE AND OHIO CANAL NATIONAL HISTORICAL PARK COMMISSION

Notice of Meeting

Notice is hereby given in accordance with the Federal Advisory Committee Act that a meeting of the Chesapeake and Ohio Canal National Historical Park Commission will be held on Saturday, February 23, 1974, at 9 a.m., at the Stephen Mather Training Center, Harpers Ferry, West Virginia.

The Commission was established by Pub. L. 91-664 to meet and consult with the Secretary of the Interior on general policies and specific matters related to the administration and development of the Chesapeake and Ohio Canal National Historical Park.

The members of the Commission are as follows:

Miss Nancy Long, Glen Echo, Maryland (Chairman)
Mrs. Caroline Freeland, Bethesda, Maryland
Hon. Vladimir A. Wahbe, Baltimore, Maryland
Mr. John C. Lewis, Hamilton, Virginia
Mr. Burton C. English, Berkeley Springs, W. Va.
Mr. James G. Banks, Washington, D.C.
Mr. Joseph H. Cole, Washington, D.C.
Mrs. Dorothy Grotos, Arlington, Virginia
Mr. Anthony Abar, Annapolis, Maryland
Mr. Ronald A. Clites, LaVale, Maryland
Mrs. Mary Miltenberger, Cumberland, Maryland
Dr. James H. Gilford, Frederick, Maryland
Mr. Grant Conway, Brookmont, Maryland
Mr. Edwin F. Wesely, Chevy Chase, Maryland
Mr. John C. Frye, Gapland, Maryland
Mr. Justice Douglas, Washington, D.C. (Special Consultant)
Mr. Rome F. Schwagel, Keedeysville, Maryland
Mr. Donald Frush, Hagerstown, Maryland

The matters to be discussed at this meeting include:

1. Dickerson Report.
2. Cumberland Report.
3. Superintendent's Report.
4. Status of the Master Plan.
5. Special Use Permits.
6. Status of Land Acquisition Program.
7. Report—Fort Duncan Historical Site.

The meeting will be open to the public. However, facilities and space for accommodating members of the public are limited and it is expected that not more than 15 persons will be able to attend the sessions. Any member of the public may file with the Commission a written statement concerning the matters to be discussed.

Persons wishing further information concerning this meeting, or who wish to submit written statements, may contact Richard L. Stanton, Assistant Director, Cooperative Activities, National Capital Parks, at 202-426-6715. Minutes of the meeting will be available for public inspection two weeks after the meeting, at the Office of National Capital Parks, Room 208, 1100 Ohio Drive, SW., Washington, D.C.

Date: February 13, 1974.

Robert M. Landau,
Liaison Officer, Advisory Commissions, National Park Service.

[FR Doc.74-3988 Filed 2-19-74;8:45 am]

DEPARTMENT OF AGRICULTURE

Forest Service

BEARTOOTH WILDERNESS, ABSAROKA WILDERNESS, AND CUT-OFF MOUNTAIN WILDERNESS

Notice of Proposed Establishment

Notice is hereby given in accordance with the provisions of the Act of September 3, 1964 (78 Stat. 890–892 (16 U.S.C. 1131–1132)), that a public hearing will be held, beginning at 9 a.m. on March 27, 1974, in the Cody Club Auditorium, Cody, Wyoming; on March 29, 1974, in the Petro Theatre, Eastern Montana College, Billings, Montana; and March 30, 1974, in Winans School Auditorium, 1015 West Clark, Livingston, Montana, on a proposal for a recommendation to be made by the Secretary of Agriculture to the President of the United States that a recommendation be submitted to the Congress for establishment of the Beartooth Wilderness, Absaroka Wilderness, and Cut-off Mountain Wilderness, comprised of 516,815 acres. The proposed Beartooth, Absaroka, and Cut-off Mountain Wildernesses are located in the Custer and Gallatin National Forests in the Counties of Carbon, Park, Stillwater, and Sweet Grass, Montana.

A brochure containing a map and information about the proposed Wildernesses may be obtained from the following:

Custer National Forest, 2602 1st Avenue North, Billings, Montana 59103.

Gallatin National Forest, Federal Building, Bozeman, Montana 59715.

Regional Forester, Northern Region, Federal Building, Missoula, Montana 59801.

Individuals and organizations may express their views by appearing at these hearings or, following the hearings, may submit written comments for inclusion in the official record to the Regional Forester, Federal Building, Missoula, Montana 59801, by April 30, 1974.

Those wishing to present oral statements at the hearings should notify the Regional Forester, Federal Building, Missoula, Montana 59801, by March 15, 1974, stating at which hearing location the views will be expressed.

Dated: February 13, 1974.

John R. McGuire,
Chief, Forest Service.

[FR Doc.74-3999 Filed 2-19-74;8:45 am]

3

APPENDIX 2

FEDERAL REGISTER: OUTER CONTINENTAL SHELF, POTENTIAL FUTURE OIL AND GAS LEASING PREPARATION OF ENVIRONMENTAL IMPACT STATEMENT

notices

This section of the FEDERAL REGISTER contains documents other than rules or proposed rules that are applicable to the public. Notices of hearings and investigations, committee meetings, agency decisions and rulings, delegations of authority, filing of petitions and applications and agency statements of organization and functions are examples of documents appearing in this section.

DEPARTMENT OF STATE

[Public Notice CM-C7]

NATIONAL REVIEW BOARD FOR THE CENTER FOR CULTURAL AND TECHNICAL INTERCHANGE BETWEEN EAST AND WEST

Postponed Meeting

The meeting of the Executive Committee of the National Review Board for the Center for Cultural and Technical Interchange Between East and West (East-West Center), announced for June 3, 1974 (39 FR 16908) at the Department of State, Room 507, SA-2, has been canceled. The meeting site has been changed to Honolulu, Hawaii and scheduled for June 21, 1974.

The meeting is being postponed to take advantage of the fact that several participants will be in Honolulu at that time on other business.

Dated: May 13, 1974.

Carol M. Owens,
Executive Secretary.

[FR Doc.74-11469 Filed 5-17-74;8:45 am]

DEPARTMENT OF THE TREASURY

Office of the Secretary

ADVISORY COMMITTEE ON REFORM OF THE INTERNATIONAL MONETARY SYSTEM

Notice of Meeting

Notice is hereby given that the Advisory Committee on Reform of the International Monetary System will meet at the Treasury Department in Washington, D.C., on June 3, 1974.

The meeting is called for the purpose of considering the basic issues involved in the current international negotiations for the reform of the international monetary system.

A determination as required by section 10(d) of the Federal Advisory Committee Act (Pub. L. 92-463) has been made that this meeting is for the purpose of considering matters falling within one or more of the exemptions to public disclosure set forth in 5 U.S.C. 552(b) and that the public interest requires such meeting be closed to public participation.

Dated: May 16, 1974.

[SEAL] Paul A. Volcker,
Under Secretary for Monetary Affairs.

[FR Doc.11666 Filed 5-17-74;9:57 am]

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

OUTER CONTINENTAL SHELF; POTENTIAL FUTURE OIL AND GAS LEASING

Preparation of Environmental Impact Statement

In order to ensure that adequate consideration is given to the environmental impacts of and alternatives to implementation of the program announced by President Nixon for an increase in potential future Outer Continental Shelf (OCS) oil and gas leasing to ten million acres in 1975, the Bureau of Land Management of the Department of the Interior will prepare an environmental impact statement for the proposed action pursuant to the provisions of section 102 (2) (C) of the National Environmental Policy Act (42 U.S.C. 4332(2)(C)). OCS areas which may be affected by the proposed program include the following:

	Approximate location
Atlantic Coast OCS areas:	
1. North Atlantic	Bay of Fundy to Cape Cod north of 40° N. latitude and south of.[1]
2. Mid-Atlantic	Cape Cod to Cape Hatteras between 40° N. to 35° N. latitude.
3. South Atlantic	Cape Hatteras to Key West south of 35° N. latitude.
Gulf of Mexico OCS areas:	
4. East Gulf	East of 88 W. longitude.
5. Central Gulf	Between 88° W. to 93° W. longitude.
6. West Gulf	West of 93° W. longitude to Mexican border.
Pacific OCS areas:	
7. Southern California Borderland	South of 34° N. latitude to Mexican border (except Santa Barbara Channel).
8. Santa Barbara	Santa Barbara Channel.
9. North and Central California	North of 34° N. latitude to California-Oregon border (except Santa Barbara Channel).
10. Washington-Oregon	Between California-Oregon border and Canadian border.
Alaska OCS areas:	
11. Cook Inlet	South of 60° N. latitude.
12. Southern Aleutian Shelf	West of 153° W. longitude.
13. Gulf of Alaska	North of 56° N. latitude, east of 153° W. longitude.
14. Bristol Bay	South of 58° N. latitude, east of 165° W. longitude.
15. Bering Sea Shelf	U.S. Waters south of 66° N. latitude.
16. Beaufort Sea	Between 142° W. and 160° W. longitude.
17. Chukchi Sea	U.S. waters north of 66° N. latitude, west of 160° W. longitude.

It is the intention of the Bureau of Land Management to prepare an environmental statement which, in general, will describe the following topics: The proposed leasing action; the management system pertaining to the proposed action, including leasing procedures, supervision, inspection, and regulation of lease operations, and monitoring of actual and threatened environmental effects of lease operations; OCS oil and gas resource potential; energy supply and demand; technology for developing oil and gas offshore; environmental settings; natural phenomena that exist or occur in particular OCS regions, and which have the potential to cause or contribute to environmental impacts arising from the proposed action; the potential environmental impacts of the proposed action, offshore and onshore, including without limitation matters such as the cumulative impact of oil and gas operations under the proposed leasing action,

5

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[1] The line drawn from a point at: 42°19.9′ N. latitude, 67°46.9′ W. longitude, thence to 42°9.3′ N. latitude, 67°40.0′ W. longitude, thence 41°42.4′ N. latitude, 67°28.8′ W. longitude, and ending at 41°15.3′ N. latitude, 66°58.9′ W. longitude.

impacts on competing uses of OCS resources, the effect of the proposed action on the level of environmental study prior to leasing and on the level of supervision of lease operations after leasing, and the degree to which environmental effects might be reduced as a result of improvements in methods of lease supervision; and the alternatives to the proposed action and their potential environmental impacts.

In due course, the Bureau of Land Management will prepare and disseminate a draft environmental statement and solicit comments on the statement from other Federal agencies, State and local governments, and interested members of the public. Moreover, it is the intention of the Bureau of Land Management to schedule public hearings, the location of which will be designated in a future notice published in the FEDERAL REGISTER, to consider the proposed action and the draft environmental statement.

The Bureau of Land Management will prepare individual environmental statements pursuant to section 102(2)(C) of the National Environmental Policy Act, supra, for each potential lease sale involved in the proposed action. This will provide a detailed environmental analysis on a tract-by-tract basis.[2]

The reasoning behind the proposed program and the determination to prepare a formal assessment of the environmental impacts of the proposal to increase OCS oil and gas leasing is as follows:

(a) Energy consumption in the United States will continue to rise. Despite conservation measures which have been instituted as a result of the recent oil embargo, all predictions indicate that there will be further increases in demand. Should domestic oil production continue to decline and demand continue to grow as in the past, imports would necessarily increase from 35 percent of U.S. consumption in 1973 to roughly half of U.S. consumption by 1980.

(b) The substantial rise in foreign oil prices in recent months also has created difficulties. If foreign oil purchases are increased, there would be a chronic balance of payments outflow which would create critical problems in international monetary affairs.

(c) An increase in domestic oil and gas production offers the greatest chance among available alternatives of avoiding increasing dependence upon potentially insecure foreign supplies of energy. While the mix between energy forms may change somewhat with rapid growth of other forms of energy such as increases in coal production and development of nuclear energy, the U.S. must continue to be heavily dependent on oil and gas through the next two decades.

(d) The Outer Continental Shelf represents a large and promising area for oil and gas exploration. The Department's Geological Survey estimates undiscovered recoverable oil resources offshore totalling 65 to 130 billion barrels of petroleum (7–14 State and 58–116 Federal) and 395 to 790 trillion cubic feet of gas (40–80 State and 355–710 Federal). Production from those resources, in addition to production from known OCS resources, would greatly help in attaining the goal of avoiding dependence on insecure foreign sources of oil and gas.

(e) The proposed action to increase OCS oil and gas leasing to 10 million acres in 1975 is a major Federal action significantly affecting the quality of the human environment.

(f) The environmental statement process articulated in the National Environmental Policy Act provides a formalized method for evaluating the environmental impact of OCS development. For example, the view—that the considerable OCS development which has occurred to date has not resulted in long lasting, unacceptable marine or shoreside environmental or socio-economic impacts—would be evaluated.

The viability of the program, and the bases therefor, will be evaluated in the decision-making processes of which the environmental statement concerning the increases in OCS leasing from approximately 3 million acres in 1974 to 10 million acres in 1975, and the individual environmental statements on the 1975 sales, are a part. Studies and views that will be considered in these decision-making processes include more than the preparation of the environmental statements referred to. The following steps have already been taken:

(a) On April 18, 1973, the President directed the Council on Environmental Quality to study the potential environmental impacts of OCS oil and gas exploration and development along the Atlantic Coast and the Gulf of Alaska. The Report of the Council on Environmental Quality, OCS Oil and Gas—An Environmental Assessment, which was submitted to the President on April 18, 1974, is undergoing a thorough review within the Department.

(b) On February 20, 1974, the Bureau of Land Management published in the FEDERAL REGISTER (39 FR 6541), a "Request for Comments" inviting and encouraging all concerned parties representing the oil and gas industry and the general public to submit information concerning areas of interest for oil and gas resource potential and areas of environmental concern. Comments received to date in response to this request are now being studied and analyzed within the Department of the Interior, and a report will be released in the near future. This is one action taken during the first tier of a new two-tier system for selecting potential OCS leasing areas and individual tracts within those areas. The Bureau of Land Management will use these rankings of areas, and its own evaluations of resource potential and need to protect environmental values, the CEQ report and views of other Federal agencies to identify areas for potential lease sales. In the second tier of the system, industry and other groups will be asked to provide their views on individual tracts within areas as in the past. Thereafter, an environmental statement for the individual lease sale would be prepared, as mentioned above, and if the sale is determined to be environmentally acceptable, the terms of the leases would be established, and the sale held.

(c) The Department is conducting an inventory and analysis of existing environmental and socio-economic data. The CEQ report represents a significant contribution to this level of effort. Contracts have been entered into with universities for more specific analyses of frontier areas such as the North Atlantic, from the Bay of Fundy to Sandy Hook, New Jersey; the mid-Atlantic, from Sandy Hook to Cape Hatteras; the South Atlantic, from Cape Hatteras to Cape Canaveral; and the Gulf of Alaska, from Cook Inlet to Unimak Island. The Department has also contracted for studies of southern California and is broadening and updating our information concerning the Gulf of Mexico.

(d) The Secretary of the Interior has created a Federal-State Research Advisory Board which will advise on the scope and conduct of baseline studies and monitoring programs for potential leasing in frontier areas of the Atlantic and Alaska. We expect to issue a number of contracts for base-line studies after receiving advice from the advisory board. Representatives of seaboard States have been invited to participate on the Board and others will be so invited.

In this connection, the Department has decided to proceed in nearly simultaneous time frames with environmental base-line studies on the Outer Continental Shelves of the Atlantic Ocean and the Gulf of Alaska in order to explore further the feasibility of oil and gas leasing in those areas. These base-line studies will consider weather, sea state, biologic populations and natural hazards. Their design will draw upon the National Oceanic and Atmospheric Administration (NOAA), Bureaus in the Department, the States, and the private sector. NOAA and the USGS have been asked to design appropriate studies for the Gulf of Alaska for early consideration by the Advisory Board. Because legal issues may delay OCS development in the Atlantic, the Gulf of Alaska may be the first frontier area in which an OCS sale could be held.

The Gulf of Alaska was identified by the CEQ in its recent report as one of the frontier OCS areas with the greatest environmental risk. The studies to be undertaken are necessary to determine the acceptability of leasing in this area. The Department believes steps should now be taken to protect the option of a sale in that area near the end of 1975 if the difficult environmental and technological problems identified in the CEQ report can be satisfactorily dealt with. The Department has no intention of leasing anywhere on the OCS if it cannot be accomplished in an environmentally acceptable way.

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[2] Decisions to prepare environmental impact statements for potential lease sales would take into account the status of pending litigation, including U.S. v. Maine et al. and U.S. v. Florida.

(e) The Department is now evaluating the feasibility of requiring permittees and lessees to furnish the Secretary with copies of all data obtained during offshore exploration and development for oil and gas. Notice of proposed rule making will be published in the FEDERAL REGISTER for public comment soon.

(f) Officials of the Department of the Interior have been involved in a continuing dialogue with environmental organizations, representatives of industry and other concerned individuals in an effort to obtain the benefit of their views relative to the environmental aspects and the oil and gas potential of the proposed action. Discussions have been held on the advisability of an OCS exploratory program that would further help to pinpoint the areas of the greatest potential production of oil and gas. These discussions have involved a number of alternative plans which include: special limited lease sales in frontier areas with a requirement for prompt exploration; leases for exploration only; a Federal exploratory drilling program; and off-structure stratigraphic drilling by both private and public entities.

Persons wishing to express their views concerning the preparation of an environmental impact statement for the proposed program to increase OCS oil and gas leasing and the other undertakings referred to may submit comments to Director, Attention 730, Bureau of Land Management, Washington, D.C. 20240.

GEORGE C. TURCOTT,
Associate Director,
Bureau of Land Management.

Approved: May 13, 1974.

JOHN C. WHITAKER,
Under Secretary of the Interior.

[FR Doc.74–11447 Filed 5–17–74;8:45 am]

Office of Hearings and Appeals

[Docket No. M74–113]

BIMBO COAL COMPANY, INC.

Petition for Modification of Application of Mandatory Safety Standard

Notice is hereby given that in accordance with the provisions of section 301(c) of the Federal Coal Mine Health and Safety Act of 1969, 30 U.S.C. 861(c) (1970), Bimbo Coal Company, Inc. has filed a petition to modify the application of 30 CFR 77.1605(k) to its No. 2 Mine located at Hall Hollow, Buchanan County, Virginia.

30 CFR 77.1605(k) provides as follows:

> Berms or guards shall be provided on the outer bank of the elevated roadways.

The alternate method which Petitioner proposes to establish in lieu of the mandatory standard is as follows:

> 1. A daily inspection of all coal-hauling vehicles shall be made and any defects detected shall be corrected before the vehicle is put into service. A record of the inspection and repair on each vehicle shall be kept and maintained by a supervisory employee.
>
> 2. Roadway surfaces shall be kept free of debris, excessive water and snow and ice, and maintained as free as practicable of small ditches (washboard effects).
>
> 3. A traffic system should be put into use for these roads requiring that the loaded vehicles have the right-of-way on the highwall side of roads regardless of their direction of travel.
>
> 4. Warning signals shall be posted designated curves, steep grades where trucks should shift to a lower gear, and where roadways are reduced to one-lane traffic. Stop signs shall be posted where one road intersects another, giving main haulage road traffic the right-of-way. Signs should also be posted designating passing points.
>
> 5. All equipment operators should be trained in the use of haulage equipment and the safety of vehicles on haulage roads.
>
> 6. All haulage vehicles shall have:
>
> (a) Original manufacturers brakes.
>
> (b) Engine or Jacobs brakes.
>
> (c) Emergency (parking) braking system.
>
> 7. Adequate supplies of crushed stone or other suitable materials shall be stored at strategic locations along the haulage roads for use when the road surface becomes slippery.
>
> 8. A minimum width of 30 feet shall be provided and maintained along two-lane roads, and where widths of less than 30 feet are provided and maintained, the roads shall be designated as single-lane roads.
>
> 9. On roads that afford only one traffic lane, a minimum width of 16 feet shall be maintained, with passing points provided at intervals of not more than 1,000 feet; if visibility is obscured by brush or other materials, passing points shall not be more than 500 feet apart.
>
> 10. Where abrupt drop-offs are present along the outer banks, super-elevation shall be provided to cause the vehicles to gravitate toward the highwall side of the road.
>
> 11. All rules of the road (traffic system) shall be posted on the bulletin boards throughout the mine area, and such rules of the road shall be made part of the training and retraining programs.

Petitioner further states that the alternative method outlined above will, at all times guarantee no less than the same measure of protection afforded the miners at the Petitioner's mine by the mandatory standard.

Persons interested in this petition may request a hearing on the petition or furnish comments on or before June 19, 1974. Such requests or comments must be filed with the Office of Hearings and Appeals, Hearings Division, U.S. Department of the Interior, 4015 Wilson Boulevard, Arlington, Virginia 22203. Copies of the petition are available for inspection at that address.

JAMES R. RICHARDS,
Director,
Office of Hearings and Appeals.

MAY 13, 1974.

[FR Doc.74–11463 Filed 5–17–74;8:45 am]

[Docket No. M 74–101]

O. C. COAL MINE #2

Petition for Modification of Application of Mandatory Safety Standard

Notice is hereby given that in accordance with the provisions of section 301 (c) of the Federal Coal Mine Health and Safety Act of 1969, 30 U.S.C. 861(c) (1970), H. W. Weaver, d.b.a. O. C. Coal Mine #2 has filed a petition to modify the application of 30 CFR 75.1405 to its O. C. Coal Mine #2 located at Gunnison, Colorado.

30 CFR 75.1405 provides as follows:

> All haulage equipment acquired by an operator of a coal mine on or after March 30, 1971, shall be equipped with automatic couplers which couple by impact and uncouple without the necessity of persons going between the ends of such equipment. All haulage equipment without automatic couplers in use in a mine on March 30, 1970, shall also be so equipped within 4 years after March 30, 1970.

Petitioner seeks a waiver of the foregoing safety standard for the following reasons:

> (1) Petitioner utilizes forty inch wide, one-ton wooden cars in its mine. These cars comprise two three-car trips which are hauled by one-half inch rope cable. The cars are manuevered by hand on the surface, and they are pulled inside by a mule.
>
> (2) The subject cars are not uncoupled in the mine. The uncoupling takes place aboveground on a flat surface when the cars are at rest.
>
> (3) The size and awkwardness of automatic couplers would create a safety hazard. In addition, the installation of said couplers would prove impractical because:
>
> (a) The cars are too small to accommodate the couplers.
>
> (b) Petitioner's personnel would be unable to manuever the cars by hand on the surface.
>
> (c) It would not be possible to manuever the cars underground by mule.
>
> (d) The mine will continue to produce coal for only three more years.
>
> (4) The alternate method will at all times guarantee no less than the same measure of protection as afforded by the application of the mandatory standard.

Persons interested in this petition may request a hearing on the petition or furnish comments on or before June 19, 1974. Such requests or comments must be filed with the Office of Hearings and Appeals, Hearings Division, U.S. Department of the Interior, 4015 Wilson Boulevard, Arlington, Virginia 22203. Copies of the petition are available for inspection at that address.

JAMES R. RICHARDS,
Director, Office of
Hearings and Appeals.

MAY 13, 1974.

[FR Doc.74–11466 Filed 5–17–74;8:45 am]

[Docket No. M 74–102]

O. C. COAL MINE #2

Petition for Modification of Application of Mandatory Safety Standard

Notice is hereby given that in accordance with the provisions of section 301 (c) of the Federal Coal Mine Health and Safety Act of 1969, 30 U.S.C. 861(c) (1970), H. L. Weaver, d.b.a. O. C. Coal Mine #2 has filed a petition to modify the application of 30 CFR 75.313 to its O. C. Coal Mine #2 located in Gunnison, Colorado.

30 CFR 75.313 provides in pertinent part as follows:

APPENDIX 3

PROPOSED SCHEDULE PROVISIONAL OCS LEASING

8

NOVEMBER 1974

PROPOSED OCS PLANNING SCHEDULE

SALE AREA		1974						1975											
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
South Texas	37		DES	PH		BSI FES	N	Sale											
Central Gulf	38	ND			T		DES	PH		FES	N	Sale							
Southern California	35		T				DES	BSI	PH			FES	N	Sale					
State - Federal Cook Inlet	1/					DES	PH		FES						Sale				
Gulf of Alaska	39	BSI				C	ND	T			DES	PH				FES	N	Sale	
Mid-Atlantic	40					C	ND	BSI	T			DES	PH				FES	N	Sale
MAFLA, Gulf of Mexico (Deep) 2/	41					C	ND	T			DES	PH				FES			
North Atlantic	42										C		ND	BSI	T			DES	
South Atlantic	43											C		ND	BSI	T			DES
Southern California	44													C		ND		T	
Bering Sea (St. George) 2/	45					C	ND	BSI	T			DES	PH				FES		
Gulf of Alaska Including Kodiak	46													BSI			C		ND
Gulf of Mexico (Deep)	47																		C
So. California (Deep)	48																		
Mid-Atlantic (Shallow & Deep)	49																	BSI	
Beaufort Sea	50							BSI											
Outer Bristol Basin	51							BSI											
North Atlantic (Shallow & Deep)	52													BSI					
So. California (Deep)	53																		
South Atlantic (Blake Plateau)	54														BSI				
Bering Sea (Norton Basin)	55														BSI				
Gulf of Alaska - Aleutian Shelf	56																		
No. California, Wash., & Oregon	57																		
Chukchi Sea (Hope Basin)	58																		

SALE AREA		1976											
		J	F	M	A	M	J	J	A	S	O	N	D
South Texas	37												
Central Gulf	38												
Southern California	35												
State - Federal Cook Inlet	1/												
Gulf of Alaska	39												
Mid-Atlantic	40												
MAFLA, Gulf of Mexico (Deep) 2/	41	N	Sale										
North Atlantic	42	PH		FES	N	Sale							
South Atlantic	43		PH			FES	N	Sale					
Southern California	44		DES		PH			FES	N	Sale			
Bering Sea (St. George) 2/	45									N	Sale		
Gulf of Alaska Including Kodiak	46		T			DES		PH			FES	N	Sale
Gulf of Mexico (Deep)	47		ND		T			DES		PH			FES
So. California (Deep)	48			C		ND		T			DES		PH
Mid-Atlantic (Shallow & Deep)	49					C		ND		T			DES
Beaufort Sea	50							C		ND		T	
Outer Bristol Basin	51								C		ND		T
North Atlantic (Shallow & Deep)	52										C		ND
So. California (Deep)	53												C
South Atlantic (Blake Plateau)	54												
Bering Sea (Norton Basin)	55												
Gulf of Alaska - Aleutian Shelf	56					BSI							
No. California, Wash., & Oregon	57					BSI							
Chukchi Sea (Hope Basin)	58					BSI							

SALE AREA		1977											
		J	F	M	A	M	J	J	A	S	O	N	D
South Texas	37												
Central Gulf	38												
Southern California	35												
State - Federal Cook Inlet	1/												
Gulf of Alaska	39												
Mid-Atlantic	40												
MAFLA, Gulf of Mexico (Deep) 2/	41												
North Atlantic	42												
South Atlantic	43												
Southern California	44												
Bering Sea (St. George) 2/	45												
Gulf of Alaska Including Kodiak	46												
Gulf of Mexico (Deep)	47	N	Sale										
So. California (Deep)	48			FES	N	Sale							
Mid-Atlantic (Shallow & Deep)	49		PH			FES	N	Sale					
Beaufort Sea	50		DES		PH			FES	N	Sale			
Outer Bristol Basin	51			DES		PH			FES	N	Sale		
North Atlantic (Shallow & Deep)	52		T			DES	PH				FES	N	Sale
So. California (Deep)	53		ND		T			DES		PH			FES
South Atlantic (Blake Plateau)	54			C		ND		T			DES		PH
Bering Sea (Norton Basin)	55					C		ND		T			DES
Gulf of Alaska - Aleutian Shelf	56							C		ND		T	
No. California, Wash., & Oregon	57								C		ND		T
Chukchi Sea (Hope Basin)	58										C		ND

SALE AREA		1978											
		J	F	M	A	M	J	J	A	S	O	N	D
South Texas	37												
Central Gulf	38												
Southern California	35												
State - Federal Cook Inlet	1/												
Gulf of Alaska	39												
Mid-Atlantic	40												
MAFLA, Gulf of Mexico (Deep) 2/	41												
North Atlantic	42												
South Atlantic	43												
Southern California	44												
Bering Sea (St. George) 2/	45												
Gulf of Alaska Including Kodiak	46												
Gulf of Mexico (Deep)	47												
So. California (Deep)	48												
Mid-Atlantic (Shallow & Deep)	49												
Beaufort Sea	50												
Outer Bristol Basin	51												
North Atlantic (Shallow & Deep)	52												
So. California (Deep)	53	N	Sale										
South Atlantic (Blake Plateau)	54			FES	N	Sale							
Bering Sea (Norton Basin)	55		PH			FES	N	Sale					
Gulf of Alaska - Aleutian Shelf	56		DES		PH			FES	N	Sale			
No. California, Wash., & Oregon	57			DES		PH			FES	N	Sale		
Chukchi Sea (Hope Basin)	58		T		DES			PH			FES	N	Sale

Curt Berklund

Director,

Bureau of Land Management

BSI	Baseline Studies Initiated
C	Call for Nominations
ND	Nominations Due
T	Announcement of Tracts
DES	Draft Environmental Statement
PH	Public Hearing
FES	Final Environmental Statement
N	Notice of Sale

Baseline studies scheduled are contingent upon scientific personnel and equipment being available to perform the studies.

The holding of sales in the Atlantic is dependent upon the outcome of pending litigation with the Atlantic States regarding jurisdiction over this area.

Sales are contingent upon technology being available for exploration and **development**. A decision whether to hold any of the lease sales listed will not be made until completion of all necessary studies of the environmental impact and the holding of public hearings; as a **result of the environmental, technical, and** economic studies employed in the decision-making process, a decision, may, in fact, be made not to hold any sale on this schedule.

1/ State may conduct sale.

2/ These sales could be contingency sales for either Gulf of Alaska (39) or Mid-Atlantic (40).

PROPOSED OCS PLANNING SCHEDULE

JUNE 1975
(REVISES NOVEMBER 1974 SCHEDULE)

SALE AREA		1974						1975												1976												1977												1978											
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
SOUTH TEXAS	37		DES	PH		BSI FES		N	Sale					S	A	L	E		H	E	L	D		I	N		F	E	B	R	U	A	R	Y		1	9	7	5																
CENTRAL GULF	38	ND			T		DES	PH		FES	N	Sale							S	A	L	E		H	E	L	D		I	N		M	A	Y		1	9	7	5																
CENTRAL GULF	38A	ND			T		DES	PH		FES	N			Sale																																							
SOUTHERN CALIF.	35		T						DES			PH	BSI		FES	N	Sale																																				
COOK INLET	1/	F	E	D	E	R	A	L		–		S	T	A	T	E		S	A	L	E		–		D	A	T	E		U	N	C	E	R	T	A	I	N																	
GULF OF ALASKA	39	BSI				C	ND			T			DES		PH		FES	N	Sale																																		
GULF OF MEXICO (GENERAL)	41						C	ND		T				DES		PH			FES	N	Sale																																
MID–ATLANTIC	40									C			BSI ND		T		DES		PH			FES	N	Sale																													
NORTH ATLANTIC	42												C		ND	BSI	T			DES		PH			FES	N	Sale																										
GULF OF MEXICO (DRAINAGE)	44																		T			DES		PH			FES	N	Sale																								
SOUTH ATLANTIC	43													C			BSI ND			T			DES		PH			FES	N	Sale																							
GULF OF ALASKA (INCLUDING KODIAK)	46													BSI			C		ND		T			DES		PH			FES	N	Sale																						
BERING SEA (ST. GEORGE)	45						C	ND				BSI		T													DES		PH			FES	N	Sale																			
GULF OF MEXICO (DEEP)	47																			C		ND			T			DES		PH			FES	N	Sale																		
SO. CALIFORNIA	48																					C		ND			T			DES		PH			FES	N	Sale																
MID–ATLANTIC	49																	BSI						C		ND			T			DES		PH			FES	N	Sale														
BEAUFORT SEA	50											BSI														C		ND			T			DES		PH			FES	N	Sale												
OUTER BRISTOL BASIN	51											BSI																C		ND			T			DES		PH			FES	N	Sale												
NORTH ATLANTIC	52															BSI														C		ND			T			DES		PH			FES	N	Sale										
CALIFORNIA GENERAL INCL. WASH. & OREGON	53																										BSI					C		ND			T			DES		PH			FES	N	Sale								
SOUTH ATLANTIC (BLAKE PLATEAU)	54																			BSI														C		ND			T			DES		PH			FES	N	Sale						
BERING SEA (NORTON BASIN)	55																					BSI														C		ND			T			DES		PH			FES	N	Sale				
GULF OF ALASKA – ALEUTIAN SHELF	56													BSI																								C		ND			T			DES		PH			FES	N	Sale		
CHUKCHI SEA HOPE BASIN	57																									BSI														C		ND			T			DES		PH			FES	N	Sale

BSI Baseline Studies Initiated
C Call for Nominations
ND Nominations Due
T Announcement of Tracts
DES Draft Environmental Statement
PH Public Hearing
FES Final Environmental Statement
N Notice of Sale
1/ State May Conduct Sale

Baseline studies scheduled are contingent upon scientific personnel and equipment being available to perform the studies.

Sales are contigent upon technology being available for exploration and development. A decision whether to hold any of the lease sales listed will not be made until completion of all necessary studies of the environmental impact and the holding of public hearings; as a result of the environmental, technical, and economic studies employed in the decision – making process, a decision, may, in fact, be made not to hold any sale on this schedule.

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

March 3, 1849

Curt Berklund
Director,
Bureau of Land Management

APPENDIX 4

DESCRIPTION OF OFFSHORE SOUTHERN CALIFORNIA OIL AND GAS TRACTS SELECTED FOR ENVIRONMENTAL STUDY

APPENDIX 4

OFFSHORE CALIFORNIA OIL AND GAS LEASE TRACTS

PROPOSED FOR LEASING IN OCS SALE #35

Tract No.	Block	Acres	Estimated Acres	Distance Shore	Distance Island	Depth (M)
Santa Rosa-Cortes North						
1	45N 82W		1920	27	3	250
2	44N 82W		4032	30	3	400
3	44N 81W		1440	31	3	250
4	44N 80W		864	31	3	250
5	43N 82W	5760		33	6	650
6	43N 81W	5760		33	4	300
7	43N 80W		5616	33	3	250
8	43N 79W		4896	29	3	250
9	43N 78W		4320	35	3	250
10	43N 77W		100	35	3	250
11	42N 81W	5760		36	8	625
12	42N 80W	5760		36	7	500
13	42N 79W	5760		40	6	375
14	42N 78W	5760		36	5	250
15	42N 77W		2592	39	3	250
16	42N 71W		990	35	3	250
17	42N 70W		2564	34	3	400
18	41N 79W	5760		39	10	625
19	41N 78W	5760		40	6	500
20	41N 77W		5616	40	3	500
21	41N 76W		2880	40	3	250
22	41N 75W		230	42	3	300
23	41N 74W		368	40	3	250
24	41N 73W		2304	35	3	250
25	41N 72W		4170	37	3	250
26	41N 71W		5275	37	3	250
27	41N 70W	5760		36	6	500
28	40N 77W	5760		40	6	250
29	40N 76W	5760		44	6	400
30	40N 75W		5529	43	3	350
31	40N 74W		5414	42	3	250
32	40N 73W	5760		41	6	250
33	40N 72W	5760		40	7	250
34	40N 71W	5760		40	8	250
35	40N 70W	5760		36	9	300
36	39N 76W	5760		46	7	625
37	39N 75W	5760		46	6	500
38	39N 74W	5760		45	8	300
39	39N 73W	5760		44	9	250
40	39N 72W	5760		43	10	250
41	39N 71W	5760		43	11	250
42	39N 70W	5760		42	12	250
43	39N 69W	5760		42	12	500
44	38N 74W	5760		48	11	500

Tract No.	Block	Acres	Estimated Acres	Distance		Depth (M)
				Shore	Island	
45	38N 73W	5760		47	12	250
46	38N 72W	5760		46	13	250
47	38N 71W	5760		45	14	250
48	38N 70W	5760		45	15	250
49	38N 69W	5760		45	15	350
50	37N 74W	5760		57	12	600
51	37N 73W	5760		50	15	250
52	37N 72W	5760		50	16	250
53	37N 71W	5760		49	17	250
54	37N 70W	5760		49	18	250
55	37N 69W	5760		46	18	250
56	36N 73W	5760		53	17	500
57	36N 72W	5760		52	18	250
58	36N 71W	5760		52	19	250
59	36N 70W	5760		51	20	250
60	36N 69W	5760		48	21	300

Santa Rosa-Cortes South

Tract No.	Block	Acres	Estimated Acres	Shore	Island	Depth (M)
61	20N 65W	5760		82	18	500
62	20N 64W	5760		81	17	500
63	20N 63W	5760		80	17	500
64	20N 62W	5760		79	17	500
65	20N 61W	5760		77	17	500
66	20N 60W	5760		75	18	500
67	19N 65W	5760		85	21	700
68	19N 64W	5760		84	20	500
69	19N 63W	5760		83	20	250
70	19N 62W	5760		81	20	250
71	19N 61W	5760		78	20	250
72	19N 60W	5760		77	21	400
73	18N 64W	5760		88	23	700
74	18N 63W	5760		86	23	500
75	18N 62W	5760		83	23	250
76	18N 61W	5760		81	23	250
77	18N 60W	5760		79	24	500
78	17N 63W	5760		87	26	750
79	17N 62W	5760		85	26	250
80	17N 61W	5760		83	26	250
81	17N 60W	5760		81	27	350
82	17N 59W	5760		79	27	500
83	17N 58W	5760		76	27	750
84	16N 67W	5760		94	30	750
85	16N 62W	5760		87	29	750
86	16N 61W	5760		87	29	300
87	16N 60W	5760		84	29	500
88	16N 59W	5760		81	30	500
89	16N 58W	5760		80	31	650
90	16N 57W	5760		78	33	700

Tract No.	Block	Acres	Estimated Acres	Distance Shore	Distance Island	Depth (M)
91	15N 67W	5760		94	32	650
92	15N 66W	5760		96	31	650
93	15N 60W	5760		86	32	600
94	15N 59W	5760		84	33	250
95	15N 58W	5760		82	34	250
96	15N 57W	5760		80	36	250
97	15N 56W	5760		79	34	600
98	14N 66W	5760		99	34	475
99	14N 65W	5760		98	34	400
100	14N 61W	5760		86	35	700
101	14N 60W	5760		88	36	600
102	14N 59W	5760		86	36	500
103	14N 58W	5760		84	37	250
104	14N 57W	5760		83	38	250
105	14N 56W	5760		86	36	250
106	14N 55W	5760		80	33	500
107	13N 66W	5760		96	37	625
108	13N 65W	5760		98	37	275
109	13N 64W	5760		96	36	650
110	13N 61W	5760		92	38	500
111	13N 60W	5760		91	39	250
112	13N 59W	5760		89	39	250
113	13N 58W	5760		87	40	250
114	13N 57W	5760		86	40	250
115	13N 56W	5760		85	37	250
116	13N 55W	5760		83	34	250
117	13N 54W	5760		81	31	500
118	12N 65W	5760		101	36	600
119	12N 64W	5760		101	39	625
120	12N 61W	5760		95	41	250
121	12N 60W	5760		93	42	250
122	12N 59W	5760		91	43	250
123	12N 58W	5760		90	43	250
124	12N 57W	5760		88	44	250
125	12N 56W	5760		87	38	250
126	12N 55W	5760		85	32	250
127	12N 54W	5760		84	33	700
128	12N 53W	5760		81	29	750
129	11N 68W	5760		110	45	625
130	11N 67W	5760		107	44	500
131	11N 65W	5760		103	43	675
132	11N 64W	5760		101	42	500
133	11N 63W	5760		99	42	725
134	11N 61W	5760		97	44	250
135	11N 60W	5760		96	45	250
136	11N 59W	5760		94	45	250
137	11N 58W	5760		92	45	250
138	11N 57W	5760		91	42	250
139	11N 56W	5760		89	40	250
140	11N 55W	5760		88	37	500

Tract No.	Block	Acres	Estimated Acres	Distance Shore	 Island	Depth (M)
141	11N 54W	5760		85	32	725
142	11N 53W	5760		84	30	750
143	10N 67W	5760		109	46	700
144	10N 66W	5760		109	46	725
145	10N 64W	5760		103	45	625
146	10N 63W	5760		103	45	700
147	10N 61W	5760		99	47	250
148	10N 60W	5760		98	46	250
149	10N 59W	5760		96	49	250
150	10N 58W	5760		95	46	250
151	10N 57W	5760		94	43	250
152	10N 56W	5760		92	41	350
153	10N 55W	5760		90	38	600
154	9N 63W	5760		104	48	750
155	9N 60W	5760		100	51	500
156	9N 59W	5760		99	50	250
157	9N 58W	5760		98	48	250
158	8N 63W	5760		107	51	750
159	8N 59W	5760		101	52	250
160	8N 58W	5760		100	50	250
161	7N 67W	5760		117	56	750
162	7N 66W	5760		114	55	725
163	7N 59W	5760		104	53	350
164	7N 58W	5760		102	51	250
165	6N 67W	5760		118	59	650
166	6N 66W	5760		117	58	650
167	6N 59W	5760		107	55	750
168	6N 58W	5760		105	53	500
169	5N 67W	5760		123	62	500
170	5N 66W	5760		120	61	625
171	4N 67W	5760		125	65	625
Santa Barbara-Santa Catalina						
172	37N 55W	5760		24	15	650
173	36N 55W	5760		26	12	300
174	36N 54W	5760		24	11	625
175	35N 55W	5760		28	9	250
176	35N 54W	5760		27	9	400
177	35N 53W	5760		25	9	725
178	35N 52W	5760		25	10	750
179	34N 57W	5760		33	10	375
180	34N 55W	5760		31	6	250
181	34N 54W	5760		29	5	250
182	34N 53W	5760		28	6	250
183	34N 52W	5760		27	8	750
184	34N 51W	5760		27	10	750
185	33N 57W	5760		36	8	300

Tract No.	Block	Acres	Estimated Acres	Distance Shore	Distance Island	Depth (M)
186	33N 55W		4896	33	3	750
187	33N 54W		4609	31	3	450
188	33N 53W		5472	31	3	250
189	33N 52W	5760		31	6	650
190	33N 51W	5760		28	9	750
191	33N 50W	5760		28	11	750
192	33N 49W	5760		23	9	750
193	33N 48W	5760		21	7	750
194	33N 47W N½, SW¼, N½SE¼ SW¼SE¼	5400		18	4	750
195	33N 46W N½, N½S½	4320		18	4	750
196	32N 57W	5760		46	7	500
197	32N 56W		4805	43	4	375
198	32N 51W	5760		29	7	750
199	32N 50W	5760		27	10	750
200	32N 49W	5760		25	8	750
201	32N 48W	5760		22	5	750
202	32N 47W N½NW¼, SW¼NW¼, W½SW¼	1800		11	4	750
203	31N 57W	5760		47	7	475
204	31N 56W		4928	44	4	250
205	31N 55W		123	43	3	250
Santa Monica Bay						
206	44N 55W		4681	3		325
207	44N 54W		2299	3		325
208	44N 53W		246	3		250
209	43N 55W	5760		6		600
210	43N 54W	5760		5		500
211	43N 53W		5236	4		450
212	43N 52W SW¼NW¼, W½SW¼, SE¼SW¼, S½SE¼		2160	3		450
213	42N 52W	5760		4		750
214	42N 51W W½NE¼, SE¼NE¼, NW¼, S½	5400		4		750
215	42N 50W NW¼SW¼, S½S½	1800		4		600
216	42N, 49W S½S½, NE¼SE¼	1800		4		500

Tract No.	Block	Acres	Estimated Acres	Distance Shore	Distance Island	Depth (M)
217	42N 48W NE¼ SE¼NW¼, S½	4680		4		500
218	42N 47W	5760		5		300
219	42N 46W	5760		5		250
220	42N 45W W½NE¼, NW¼, S½	5040		4		250
221	42N 44W W½SW¼, SE¼SW¼	1080		4		250
222	41N 49W	5760		5		750
223	41N 48W	5760		7		600
224	41N 47W	5760		8		500
225	41N 46W	5760		8		250
226	41N 45W	5760		6		250
227	41N 44W W½, W½SE¼	3600		4		250
228	40N 48W	5760		10		750
229	40N 47W	5760		11		750
230	40N 46W	5760		10		300
231	40N 45W	5760		7		250
232	40N 44W	5760		4		250
233	40N 43W SW¼SW¼	360		4		250
234	39N 46W	5760		11		250
235	39N 45W	5760		8		250
236	39N 44W	5760		5		250
237	39N 43W W½NW¼	720		4		250
238	38N 45W	5760		7		700
239	38N 44W W½, W½E½	4320		4		400
240	37N 45W	5760		7		750
241	37N 44W NW¼NE¼, S½NE¼, NW¼, S½	5400		3		750
San Pedro Bay						
242	36N 36W		24	3		250
243	35N 41W NW¼NW¼, S½NW¼, S½	3960		4		750
244	35N 40W S½SW¼, S½SE¼	1440		4		500
245	35N 39W		2957	3		250
246	35N 38W		4928	5		250
247	35N 37W		5236	4		250
248	35N 36W		3756	3		250
249	35N 35W		123	3		250
250	34N 41W	5760		8		750

Tract No.	Block	Acres	Estimated Acres	Distance Shore	Distance Island	Depth (M)
251	34N 40W	5760		7		400
252	34N 39W	5760		7		250
253	34N 38W	5760		9		250
254	34N 37W	5760		8		250
255	34N 36W	5760		6		250
256	34N 35W		3696	3		250
257	33N 41W	5760		11		750
258	33N 40W	5760		10		700
259	33N 39W	5760		10		250
260	33N 38W	5760		11		250
261	33N 37W	5760		10		250
262	33N 36W	5760		8		250
263	33N 35W	5760		7		250
264	33N 34W SW¼NW¼, SW¼, NW¼SE¼, S½SE¼	2880		4		250
265	32N 39W	5760		13		750
266	32N 38W	5760		14		500
267	32N 37W	5760		13		250
268	32N 36W	5760		10		400
269	32N 35W	5760		9		350
270	32N 34W	5760		7		275
271	32N 33W SW¼NE¼, NW¼, S½	4680		4		300
272	32N 32W NW¼SW¼, S½SW¼	1080		4		500
273	31N 37W	5760		15		500
274	31N 36W	5760		13		500
275	31N 35W	5760		11		500
276	31N 34W	5760		10		500
277	31N 33W	5760		9		500
278	31N 32W	5760		7		500
279	31N 31W SW¼NW¼, SW¼, SW¼SE¼	2160		4		500
280	30N 36W	5760		15		550
281	30N 35W	5760		14		500
282	30N 34W	5760		11		500
283	30N 33W	5760		7		500
284	30N 32W	5760		9		500
285	30N 31W	5760		7		500
286	30N 30W SW¼NW¼, NW¼SW¼, S½SW¼	1440		4		500
287	29N 35W	5760		17		450
288	29N 34W	5760		15		400
289	29N 33W	5760		12		500
290	29N 32W	5760		9		500
291	29N 31W	5760		7		500

			Estimated	Distance		Depth
Tract No.	Block	Acres	Acres	Shore	Island	(M)
292	29N 30W S½NE¼, NW¼NE¼, NW¼, S½	5400		4		500
293	28N 34W	5760		16		600
294	28N 33W	5760		14		500
295	28N 32W	5760		12		500
296	28N 31W	5760		10		500
297	28N 30W	5760		8		500

TOTAL: 297 Tracts 1,554,815 Acres

APPENDIX 5

OCS OPERATING ORDERS, NOS. 1 THROUGH 12; PACIFIC AREA

INDEX

OCS Order — *Page*

1 MARKING OF WELLS, PLATFORMS, AND FIXED STRUCTURES 1-1
- *Identification of Platforms or Fixed Structures 1-1*
- *Identification of Non-Fixed Platforms or Structures 1-2*
- *Identification of Individual Wells. 1-2*

2 DRILLING PROCEDURES 2-1
- *Well Casing 2-1*
- *Blowout Prevention Equipment. 2-4*
- *Mud Program - General 2-7*

3 PLUGGING AND ABANDONMENT OF WELLS 3-1
- *Permanent Abandonment 3-1*
- *Temporary Abandonments. 3-3*

4 SUSPENSIONS AND DETERMINATION OF WELL PRODUCIBILITY 4-1
- *Oil Wells 4-1*
- *Gas Wells 4-1*
- *Witnessing and Results. 4-2*

5 INSTALLATION OF SUBSURFACE SAFETY DEVICE. 5-1

6 PROCEDURE FOR COMPLETION OF OIL AND GAS WELLS 6-1
- *Wellhead Equipment and Testing Procedures 6-1*
- *Subsurface Safety Device. 6-2*
- *Procedures for Multiple or Tubingless Completions 6-2*

7 POLLUTION AND WASTE DISPOSAL. 7-1
- *Pollution Prevention. 7-2*
- *Inspections and Reports 7-3*
- *Control and Removal. 7-4*

8 APPROVAL PROCEDURE FOR INSTALLATION AND OPERATION OF PLATFORMS, FIXED AND MOBILE STRUCTURES, AND ARTIFICIAL ISLANDS. 8-1
- *General Design. 8-1*
- *Application 8-2*
- *Certified Plan. 8-3*
- *Safety and Pollution Control Equipment and Procedures 8-3*
- *Welding Practices and Procedures. 8-11*

9 APPROVAL PROCEDURE FOR PIPELINES. 9-1
- *General Design. 9-1*
- *Application 9-3*
- *Completion Report 9-4*

10 DRILLING OF TWIN CORE HOLES 10-1

11 OIL AND GAS PRODUCTION RATES 10-1

12 PUBLIC INSPECTION OF RECORDS 12-1

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
BRANCH OF OIL AND GAS OPERATIONS
PACIFIC REGION

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

MARKING OF WELLS, PLATFORMS, AND FIXED STRUCTURES

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.37. Section 250.37 provides as follows:

> *Well designations. The lessee shall mark promptly each drilling platform or structure in a conspicuous place, showing his name or the name of the operator, the serial number of the lease, the identification of the wells, and shall take all necessary means and precautions to preserve these markings.*

The operator shall comply with the following requirements. Any departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. *Identification of Platforms or Fixed Structures. Platforms and structures shall be identified at two diagonal corners of the platform or structure by a sign with letters and figures not less than 12 inches in height with the following information: the name of lease operator, the OCS lease number and the platform or structure designation. The information shall be abbreviated as in the following example:*

   "The Blank Oil Company operates 'C' platform on lease OCS-P 0000".

   The identifying sign on the platform would show:

   "BOC - OCS-P 0000 - C"

2. *Identification of Non-Fixed Platforms or Structures. Floating semi-submersible platforms, bottom-setting mobile and floating drilling ships shall be identified by one sign with letters and figures not less than 12 inches in height affixed to the derrick to be visible from off the vessel with the following information: the name of the lease operator and the OCS lease number.*

3. Identification of Individual Wells on Platforms. The OCS lease and well number shall be painted on, or a sign affixed to, each singly completed well. In multiple completed wells each completion shall be individually identified at the wellhead. All identifying signs shall be maintained in a legible condition.

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
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BRANCH OF OIL AND GAS OPERATIONS
PACIFIC REGION

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

DRILLING PROCEDURES

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.34, 250.41, and 250.91. All exploratory wells drilled for oil and gas shall be drilled in accordance with the provisions of this Order. Initial development wells drilled for oil and gas shall be drilled in accordance with the provisions of this Order, and these provisions shall continue in effect until field rules are issued. After field rules have been established by the Supervisor, development wells in the individual fields shall be drilled in accordance with such rules.

Where sufficient geologic and engineering information is obtained through exploratory drilling, operators may make application to the Supervisor for the establishment of field rules, but such applications shall be made before more than five development wells have been drilled in a field. When required by the Supervisor, operators shall make application for the establishment of field rules for existing fields containing more than five development wells on the date of this Order.

Each Application to Drill (Form 9-331C) for exploratory wells and development wells not covered by field rules shall include all information required under 30 CFR 250.91 and the detailed casing, cementing, mud, and blowout prevention program for the well and shall comply with the following requirements. Any departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. *Well Casing. All wells shall be cased and cemented in accordance with the requirements of 30 CFR 250.41(a)(1). The Application to Drill (Form 9-331C) shall contain a statement that all zones which contain oil, gas, or fresh water shall be fully protected by casing and cement. All casing strings shall be new pipe or equivalent. For the purpose of this Order, the several casing strings in order of normal installation are drive or structural casing, conductor casing, surface casing, intermediate casing, protective casing, and production casing. These casing strings shall be run and cemented prior to drilling below the specified setting depths, subject to minor variations to permit the casing to be set in a competent bed. All depths refer to true vertical depth (TVD) below the ocean floor, unless otherwise specified. Determination*

of proper casing setting depths shall be based upon all geological and engineering factors including the presence or absence of hydrocarbons. Formation fracture gradients and formation pressures shall be taken into account.

A. Drive or Structural Casing. This casing shall be set by drilling, driving, or jetting to a depth of approximately 100 feet below the ocean floor to support unconsolidated deposits and to provide hole stability for initial drilling operations. If drilled in, the drilling fluid shall be a type that will not pollute the ocean. This casing may be omitted, when approved by the Supervisor, if there is geological evidence that hydrocarbons will not be encountered while drilling the hole for the conductor casing and is not needed for hole stability.

B. Conductor Casing. This casing shall be set at a minimum depth of 300 feet or a maximum depth of 500 feet below the ocean floor; provided, however, the conductor casing shall be set before drilling into shallow formations known to contain oil or gas or, if unknown, upon encountering such formations.

C. Surface Casing. This casing shall be set at a minimum depth of 1,000 feet or a maximum depth of 1,200 feet below the ocean floor, but may be set as deep as 1,500 feet in the event the conductor casing is set at least 450 feet below the ocean floor.

D. Intermediate Casing. This casing shall be set if the proposed total depth of the well is greater than 3,500 feet (TVD in feet from rotary table). When surface casing is set at 1,500 feet the intermediate casing may be omitted if the proposed total depth of the well is not greater than 4,500 feet. Otherwise, the intermediate casing shall be set before drilling below the setting depths specified in the following table:

Proposed Total Depth of Well or Proposed Depth of First Full String of Protective Casing (TVD in feet from Rotary Table)	Setting Depths for Intermediate Casing (TVD in Feet Below Ocean Floor)	
	Minimum	Maximum
3,500 - 4,500	1,500	3,500
4,500 - 6,000	1,750	3,500
6,000 - 9,000	2,250	3,500
9,000 - 11,000	2,750	3,500
11,000 - 13,000	3,250	3,500
13,000 - Below	3,450	3,550

E. *Protective Casing.* *When required by well conditions, this casing shall be set at any time when drilling below the surface casing. If a liner is used as a protective string, the lap shall be tested by a fluid entry or pressure test to determine whether a seal between the liner top and next larger string has been achieved. The test shall be recorded on the driller's log and shall be witnessed by a Geological Survey representative.*

F. *Production Casing.* *This casing shall be set before completing the well for production. When a blank or combination liner is run and cemented as production casing, the testing of the lap between the liner top and next larger string shall be conducted as in the case of protective liners. The surface casing shall never be used as production casing.*

G. *Casing Cementing.* *The structural (if drilled or jetted), conductor, and surface casings shall be cemented with a quantity sufficient to fill the annular space back to the ocean floor. The intermediate casing shall be cemented with a quantity sufficient to fill the annular space back to the ocean floor or at least 100 feet into the next larger string of pipe. The protective casing shall be cemented so that all hydrocarbon zones and abnormal pressure intervals are isolated. The production casing shall be cemented in a manner necessary to cover or isolate all zones which contain hydrocarbons and abnormal pressure intervals, but in any case, a calculated volume sufficient to fill the annular space at least 500 feet above the uppermost hydrocarbon zone, not previously cased, must be used. Whenever there are indications of improper cementing, such as lost circulation, cement channeling, or mechanical failure of equipment, a temperature or cement bond survey shall be run, either before or after remedial cementing, to aid in determining whether the casing is properly cemented. If the annular space is not adequately cemented by the primary operation, the operator shall either (1) recement, (2) squeeze the shoe of the casing with cement, either by drilling out and squeezing or by squeezing through perforations at the interval of competent formation nearest the shoe, or (3) displace with cement in sufficient quantity to fill the annular space. Upon determining that the casing shoe has been* adequately cemented the operator may commence further drilling operations provided that prior to abandonment of the well the annular space behind the conductor, surface, and intermediate casings shall be cemented back to the ocean floor or 100 feet into the next larger string of pipe.

H. Pressure Testing. Prior to drilling the plug after cementing, all casing strings, except the drive or structural casing, shall be pressure tested as shown in the table below. This test shall not exceed the rated working pressure of the casing. If the pressure declines more than 10 percent in 30 minutes, or if there is other indication of a leak, corrective measures must be taken until a satisfactory test is obtained.

Casing String	Minimum Pressure Test (psi)
Conductor	200
Surface and Intermediate	1,000
Protective	1,500 or 0.2 psi/ft., whichever is greater
Liner	1,500 or 0.2 psi/ft., whichever is greater
Production	1,500 or 0.2 psi/ft., whichever is greater

After cementing any of the above strings, drilling shall not be commenced until a time lapse of:

(1) 24 hours, or

(2) 8 hours under pressure for the conductor casing string and 12 hours under pressure for all other casing strings. (Cement is considered under pressure if one or more float valves are employed and are shown to be holding the cement in place or when other means of holding pressure are used.)

All casing pressure tests shall be recorded on the driller's log.

2. Blowout Prevention Equipment. Blowout preventers and related well control equipment shall be installed, used, and tested in a manner necessary to prevent blowouts. Prior to drilling below the conductor casing, blowout prevention equipment shall be installed and maintained ready for use until drilling operations are completed as follows:

A. *Conductor Casing. Before drilling below this string, at least one remotely controlled hydril type blowout preventer and equipment for circulating the drilling fluid to the drilling structure or vessel shall be installed. To avoid formation fracturing from complete shut-in of the well, a pipe of adequate diameter with control valves shall be installed below the blowout preventer so as to permit the diversion of hydrocarbons and other fluids; except that when the blowout preventer assembly is on the ocean floor, the choke and kill lines shall be equipped to permit the diversion of hydrocarbons and other fluids.*

B. *Surface Casing. Before drilling below this string the blowout prevention equipment shall include a minimum of:*

  (1) *three remotely controlled, hydraulically operated blowout preventers with a rated working pressure which exceeds the maximum anticipated surface pressure, including one equipped with pipe rams, one with blind rams, and one hydril type;*

  (2) *a drilling spool with side outlets, if side outlets are not provided in the blowout preventer body;*

  (3) *a choke manifold;*

  (4) *a kill line; and*

  (5) *a fill-up line.*

C. *Intermediate Casing. Before drilling below this string the blowout prevention equipment shall include a minimum of:*

  (1) *four remotely controlled, hydraulically operated blowout preventers with a rated working pressure which exceeds the maximum anticipated surface pressure, including at least one equipped with pipe rams, one with blind rams, and one hydril type;*

  (2) *a drilling spool with side outlets, if side outlets are not provided in the blowout preventer body;*

(3) *a choke manifold;*

(4) *a kill line; and*

(5) *a fill-up line.*

D. Testing. *Ram-type blowout preventers and related control equipment shall be tested to the rated working pressure of the stack assembly or to the working pressure of the casing, whichever is the lesser, at the following times:*

(1) *when installed;*

(2) *before drilling out after each string of casing is set;*

(3) *not less than once each week while drilling; and*

(4) *following repairs that require disconnecting a pressure seal in the assembly. The hydril type blowout preventer shall be tested to 70 percent of the above pressure requirements.*

While drill pipe is in use ram-type blowout preventers shall be actuated to test proper functioning once each trip, but in no event less than once each day. The hydril type blowout preventer shall be actuated on the drill pipe once each week. Accumulators or accumulators and pumps shall maintain a reserve capacity at all times to provide for repeated operation of hydraulic preventers. A blowout prevention drill shall be conducted weekly for each drilling crew to insure that all equipment is operational and that crews are properly trained to carry out emergency duties. All blowout preventer tests and crew drills shall be recorded on the driller's log.

E. Other Equipment. *An inside blowout preventer assembly (back pressure valve) and a full opening drill string safety valve in the open position shall be maintained on the rig floor at all times while drilling operations are being conducted. Valves shall be maintained on the rig floor to fit all pipe in the drill string. Also, a socket type, sealing coupling capable of being dropped* *over exposed drill pipe with a full opening safety valve above it shall be maintained on the rig floor for control situations where flow prevents installation of a safety valve. A top kelly cock shall be installed below the swivel and another at the bottom of the kelly of such design that it can be run through the blowout preventers.*

3. *Mud Program - General. The characteristics, use, and testing of drilling mud and the conduct of related drilling procedures shall be such as are necessary to prevent the blowout of any well. Quantities of mud materials sufficient to insure well control shall be maintained readily accessible for use at all times.*

   A. *Mud Control. Before starting out of the hole with drill pipe, the mud shall be circulated with the drill pipe just off bottom until the mud is properly conditioned. Proper conditioning requires, at a minimum, circulation to the extent that the annulus volume is displaced. When coming out of the hole with drill pipe, the annulus shall be filled with mud before the mud level drops below 100 feet, and a mechanical device for measuring the amount of mud required to fill the hole shall be utilized. The volume of mud required to fill the hole shall be watched, and any time there is an indication of swabbing or influx of formation fluids, the necessary safety device(s) required in subparagraph 2.E. above shall be installed on the drill pipe, the drill pipe shall be run to bottom and the mud properly conditioned. The mud shall not be circulated and conditioned except on or near bottom, unless well conditions prevent running the pipe to bottom. The mud in the hole shall be circulated or reverse circulated prior to pulling drill stem test tools from the hole.*

   B. *Mud Testing Equipment. Mud testing equipment shall be maintained on the drilling platform at all times, and mud tests consistent with good operating practice shall be performed daily, or more frequently as conditions warrant.*

   The following mud system monitoring equipment must be installed (with derrick floor indicators) and used throughout the period of drilling after setting and cementing the conductor casing:

(1) Recording mud pit level indicator to determine mud pit volume gains and losses. This indicator shall include a visual or audio warning device.

(2) Mud volume measuring device for accurately determining mud volumes required to fill the hole on trips.

(3) Mud return or full hole indicator to determine when returns have been obtained, or when they occur unintentionally, and additionally to determine that returns essentially equal the pump discharge rate.

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

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NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

PLUGGING AND ABANDONMENT OF WELLS

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.15. The operator shall comply with the following minimum plugging and abandonment procedures which have general application to all wells drilled for oil and gas. Plugging and abandonment operations must not be commenced prior to obtaining approval from an authorized representative of the Geological Survey. Oral approvals shall be in accordance with 30 CFR 250.13. Any departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. *Permanent Abandonment.*

   A. *Isolation in Uncased Hole.* *In uncased portions of wells, cement plugs shall be spaced to extend 100 feet below the bottom to 100 feet above the top of any oil, gas, and fresh water zones so as to isolate fluids in the strata in which they are found and to prevent them from escaping into other strata.*

   B. *Isolation of Open Hole.* *Where there is open hole (uncased and open into the casing string above) below the casing, a cement plug shall be placed in the deepest casing string by (1) or (2) below, or in the event lost circulation conditions exist or are anticipated, the plug may be placed in accordance with (3) below:*

      (1) A cement plug placed by displacement method so as to extend a minimum of 100 feet above and 100 feet below the casing shoe.

      (2) A cement retainer with effective back pressure control set not less than 50 feet, nor more than 100 feet, above the casing shoe with a cement plug calculated to extend at least 100 feet below the casing shoe and 50 feet above the retainer.

(3) *A permanent type bridge plug set within 150 feet above the casing shoe with 50 feet of cement on top of the bridge plug. This plug shall be tested prior to placing subsequent plugs.*

C. *Plugging or Isolating Perforated Intervals. A cement plug shall be placed opposite all open perforations (perforations not squeezed with cement) extending a minimum of 100 feet above and 100 feet below the perforated interval or down to a casing plug whichever is less. In lieu of the cement plug, a bridge plug set at a maximum of 150 feet above the open perforations of each separate interval with 50 feet of cement on top may be used provided the perforations are isolated from the hole below.*

D. *Plugging of Casing Stubs. If casing is cut and recovered, thereby leaving a stub inside the next larger string, a cement plug will be set so as to extend 100 feet above and 100 feet below the stub, or a retainer set 50 feet above the stub with 150 feet of cement set below and 50 feet above. A permanent bridge plug set 50 feet above the stub and capped with 50 feet of cement shall be used if the foregoing methods cannot be used. However, if the stub is below the next larger string, plugging must be accomplished in accordance with subparagraph A and B above.*

E. *Plugging of Annular Space. No annular space that extends to the ocean floor shall be left open to drilled hole below. If this condition exists, the annulus shall be plugged with cement.*

F. *Surface Plug Requirement. A cement plug of at least 150 feet, with the top of the plug 150 feet or less below the ocean floor, shall be placed in the smallest string of casing which extends to the surface.*

G. *Testing of Plugs. The setting and location of the first plug below the 150-foot surface plug shall be verified by placing the weight of the drill string or a minimum pipe weight of 15,000 pounds on the plug, whichever is greater. The top of plugs placed opposite open hole or perforations shall be verified as to location.*

H. Mud. *Each of the respective intervals of the hole between the various plugs shall be filled with mud fluid of sufficient density to exert hydrostatic pressure exceeding the greatest formation pressure encountered while drilling such interval.*

I. Clearance of Location. *All casing and anchor piling shall be severed and removed to at least 5 feet below the ocean floor and the ocean floor shall be cleared of any obstructions.*

2. Temporary Abandonments. *Any drilling well which is to be temporarily abandoned shall be mudded and cemented as required for permanent abandonment except for requirements of subparagraphs 1.E., F., and I. above. When casing extends above the ocean floor, a mechanical bridge plug (retrievable or permanent) shall be set in the casing between 15 and 200 feet below the ocean floor.*

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

OCS Order No. 4
June 1, 1971

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
BRANCH OF OIL AND GAS OPERATIONS
PACIFIC REGION

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

SUSPENSIONS AND DETERMINATION OF WELL PRODUCIBILITY

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.12(d)(1). An OCS lease provides for extension beyond its primary term for as long as oil or gas may be produced from the lease in paying quantities. The term "paying quantities" as used herein means production in quantities sufficient to yield a return in excess of operating costs. An OCS lease may be maintained beyond the primary term, in the absence of actual production, when a suspension of production has been approved. Any application for suspension of production for an initial period shall be submitted prior to the expiration of the term of a lease. The Supervisor may approve a suspension of production provided at least one well has been drilled on the lease and he determines it to be capable of being produced in paying quantities. The temporary or permanent abandonment of a well will not preclude approval of a suspension of production as provided in 30 CFR 250.12(d)(1). Any departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

A well may be determined to be capable of producing in paying quantities when the requirements below have been met.

1. *Oil Wells. A deliverability test of at least two hours' duration after the well flow has stabilized which proves that the well is capable of producing oil in paying quantities.*

2. *Gas Wells. A four-point back pressure test or a measured deliverability test of at least two hours' duration after the well flow has stabilized which proves that the well is capable of producing gas or gas and condensate in paying quantities.*

3. *Witnessing and Results*. *All tests must be witnessed by an authorized representative of the Geological Survey. Test data accompanied by operator's affidavit, or third-party test data, may be accepted in lieu of a witnessed test provided prior approval is obtained from the appropriate district office. The results of the witnessed or accepted test must justify a determination that the well is capable of producing in paying quantities.*

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

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NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

INSTALLATION OF SUBSURFACE SAFETY DEVICE

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.41(b). Section 250.41(b) provides as follows:

> *(b) Completed wells. In the conduct of all its operations, the lessee shall take all steps necessary to prevent blowouts, and the lessee shall immediately take whatever action is required to bring under control any well over which control has been lost. The lessee shall: (1) in wells capable of flowing oil or gas, when required by the supervisor, install and maintain in operating condition storm chokes or similar subsurface safety devices; (2) for producing wells not capable of flowing oil or gas, install and maintain surface safety valves with automatic shut-down controls; and (3) periodically test or inspect such devices or equipment as prescribed by the supervisor.*

The operator shall comply with the following requirements. Any departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. *All wells capable of flowing oil or gas shall be equipped with a subsurface safety device installed at a depth of 100 feet or more below the ocean floor. Such device shall be installed in all oil and gas wells, including artificial lift wells, unless proof is provided to the Supervisor that such wells are incapable of any natural flow. For shut-in wells capable of flowing oil or gas, a tubing plug may be installed, in lieu of a subsurface safety device, and such plug shall be installed when required by the Supervisor.*

2. *Subsurface safety devices shall be adjusted, installed, and maintained to insure reliable operation. Each subsurface safety device and tubing plug installed in a well shall be*

tested at intervals not exceeding 6 months. Where a safety valve is set in a landing nipple and is of the type that is controlled from the surface by a hydraulic line or other means, the valve may be tested from the surface to insure proper functioning. If the valve does not operate properly it shall be removed, repaired, reinstalled or replaced and again checked for proper operation.

When a subsurface safety device is removed from a well for repair or replacement, a standby subsurface safety device or tubing plug shall be available at the well location. In the event of an emergency such device shall be immediately installed within the limits of practicability, consideration being given to time, equipment, and personnel safety.

Subsurface safety devices that are an integral part of the tubing string shall be tested at intervals not exceeding six months and, if the test is unsatisfactory, shall be replaced or a removable subsurface device shall be installed.

All wells in which a subsurface safety device or tubing plug is installed shall have the tubing-casing annulus sealed below the valve or plug setting depth.

3. *In all tubing installations made after the effective date of this Order, the tubing string shall be equipped with a surface-controlled subsurface safety device. In high-flow-rate wells or wells producing sand, areas of turbulence above and below such devices shall be protected by flow couplings or other protective equipment. Wells which are presently equipped with direct-controlled subsurface safety devices shall have surface-controlled subsurface safety devices installed the first time the tubing is pulled after the effective date of this Order, or within one year after the effective date of this Order, whichever occurs sooner. The control system for the surface-controlled subsurface safety devices shall be an integral part of the platform shut-in system.*

4. *The well completion report on Form 9-330 and any subsequent report of workover on Form 9-331 shall state the type and the depth of the subsurface safety device or tubing plug installed in the well or state that the requirement has been waived.*

5. *The operator shall maintain records, available at a structure in the field to any authorized representative of the Geological Survey, showing the present status and past history of each subsurface safety device or tubing plug, including dates and details of inspection, testing, repairing, adjustment and reinstallation or replacement. The operator shall submit a copy of such records semiannually to the District Engineer.*

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
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NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

PROCEDURE FOR COMPLETION OF OIL AND GAS WELLS

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.92. Any departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. *Wellhead Equipment and Testing Procedures.*

   A. *Wellhead Equipment. All completed wells shall be equipped with casingheads, wellhead fittings, valves, and connections with a rated working pressure equal to or greater than the surface shut-in pressure of the well. Connections and valves shall be designed and installed to permit fluid to be pumped between any two strings of casing. Two master valves shall be installed on the tubing in wells with a surface pressure in excess of five thousand pounds per square inch. All wellhead connections shall be assembled and tested, prior to installation, by a fluid pressure which shall be equal to 1.5 times the rated working pressure of the fitting to be installed.*

   B. *Testing Procedure. Any wells showing sustained pressure on the casinghead, or leaking gas or oil between the production casing and the next larger casing string, shall be tested in the following manner: The well shall be killed with water or mud and pump pressure applied to the production casing string. Should the pressure at the casinghead reflect the applied pressure, corrective measures must be taken and the casing shall again be tested in the same manner. This testing procedure shall be used when the origin of the pressure cannot be determined otherwise.*

2. *Subsurface Safety Device.* All completed wells shall meet the requirements prescribed in OCS Order No. 5.

3. *Procedures for Multiple or Tubingless Completions.*

A. *Multiple Completions.*

(1) Information shall be submitted on, or attached to, Form 9-331 showing top and bottom of all zones proposed for completion or alternate completion, including a partial electric log and a diagrammatic sketch showing such zones and equipment to be used.

(2) When zones approved for multiple completion become intercommunicated the lessee shall immediately repair and separate the zones after approval is obtained.

B. *Tubingless Completions.*

(1) All tubing strings in a multiple completed well shall be run to the same depth below the deepest producible zone.

(2) The tubing string(s) shall be new pipe or equivalen and shall be cemented with a sufficient volume to extend a minimum of 500 feet above the uppermost producible zone.

(3) A temperature or cement bond log shall be run in all tubingless completion wells where lost circulation or other unusual circumstances occur during the cementing operations.

(4) Information shall be submitted on, or attached to, Form 9-331 showing the top and bottom of all zones proposed for completion or alternate completion, including a partial electric log and a diagrammatic sketch showing such zones and equipment to be used.

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G. Wayland

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Chief, Conservation Division

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NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

POLLUTION AND WASTE DISPOSAL

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.43. Section 250.43 provides as follows:

> *(a) The lessee shall not pollute land or water or damage the aquatic life of the sea or allow extraneous matter to enter and damage any mineral- or water-bearing formation. The lessee shall dispose of all liquid and non-liquid waste materials as prescribed by the supervisor. All spills or leakage of oil or waste materials shall be recorded by the lessee and, upon request of the supervisor, shall be reported to him. All spills or leakage of a substantial size or quantity, as defined by the supervisor, and those of any size or quantity which cannot be immediately controlled also shall be reported by the lessee without delay to the supervisor and to the Coast Guard and the Regional Director of the Federal Water Pollution Control Administration. All spills or leakage of oil or waste materials of a size or quantity specified by the designee under the pollution contingency plan shall also be reported by the lessee without delay to such designee.*
>
> *(b) If the waters of the sea are polluted by the drilling or production operations conducted by or on behalf of the lessee, and such pollution damages or threatens to damage aquatic life, wildlife, or public or private property, the control and total removal of the pollutant, wheresoever found, proximately resulting therefrom shall be at the expense of the lessee. Upon failure of the lessee to control and remove the pollutant the supervisor, in cooperation with other appropriate agencies of the Federal, State and local governments, or in cooperation with the lessee, or both, shall have the right to accomplish the control and removal of the pollutant in accordance with any established contingency plan for combating oil spills or by other means at the cost of the lessee. Such action shall not relieve the lessee of any responsibility as provided herein.*

(c) The lessee's liability to third parties, other than for cleaning up the pollutant in accordance with paragraph (b) of this section, shall be governed by applicable law.

The operator shall comply with the following requirements. Any departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. Pollution Prevention. In the conduct of all oil and gas operations, the operator shall not pollute land or water. The operator shall comply with the following pollution prevention requirements.

A. Liquid Disposal.

(1) The disposal of produced waste water and sewage shall be in accordance with the provisions of OCS Order No. 8.

(2) Oil shall not be disposed of into ocean waters.

(3) Liquid waste materials containing substances which may be harmful to aquatic life or wildlife, or injurious in any manner to life or property, shall be treated to avoid disposal of harmful substances into the ocean waters.

(4) Drilling mud containing oil or toxic substances shall not be disposed of into the ocean waters.

B. Solid Waste Disposal.

(1) Drill cuttings, sand, and other solids containing oil shall not be disposed of into the ocean waters.

(2) Mud containers and other solid waste materials shall be transported to shore for disposal.

C. Production Facilities.

(1) All production facilities, such as separators, tanks, treaters, and other equipment, shall be operated and maintained at all times in a manner necessary to prevent pollution.

(2) The operator's personnel shall be thoroughly instructed in the techniques of equipment maintenance and operation for the prevention of pollution. Non-operator personnel shall be informed in writing, prior to executing contracts, of the operator's obligations to prevent pollution.

2. Inspections and Reports. The operator shall comply with the following pollution inspection and reporting requirements and operators shall comply with such instructions or orders as are issued by the Supervisor for the control or removal of pollutants:

A. Pollution Inspections.

(1) Manned drilling and production facilities shall be inspected daily to determine if pollution is occurring. Such maintenance or repairs as are necessary to prevent pollution of ocean waters shall be immediately undertaken and performed.

(2) Unattended facilities, including those equipped with remote control and monitoring systems, shall be inspected at intervals as prescribed by the District Engineer and necessary maintenance or repairs immediately made thereto.

B. Pollution Reports.

(1) All spills or leakage of oil and liquid pollutants shall be reported orally without delay to the District Engineer and the Coast Guard and shall be followed by a written report to the District Engineer showing the cause, size of spill, and action taken.

(2) All spills or leakage of oil and liquid pollutants of a substantial size or quantity and those of any size or quantity which cannot be immediately controlled, shall be reported orally without delay to the Supervisor, the District Engineer, the Coast Guard, and the Regional Director, Environmental Protection Agency.

(3) Operators shall notify each other upon observation of equipment malfunction or pollution resulting from another's operation.

3. *Control and Removal.*

   A. *Corrective Action. Immediate corrective action shall be taken in all cases where pollution has occurred. Each operator shall have an emergency plan for initiating corrective action to control and remove pollution and such plan shall be filed with the Supervisor. Corrective action taken under the plan shall be subject to modification when directed by the Supervisor.*

   B. *Equipment. Standby pollution control equipment shall be maintained at each operation or shall be immediately available to each operator at an onshore location. This equipment shall include, but need not be limited to, containment booms, skimming apparatus, and chemical dispersants and shall be available prior to the commencement of operations. This equipment shall be the most effective available resulting from the current state of pollution control and removal research and development efforts. The equipment shall be regularly inspected and maintained in good condition for use. The equipment and the location of land bases shall be approved by the Supervisor. Chemical dispersants shall not be used without prior approval of the Supervisor. The operator shall notify the Supervisor of the location at which such equipment is located for operations conducted on each lease. All changes in location and equipment maintained at each location shall be approved by the Supervisor.*

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

UNITED STATES
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NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

APPROVAL PROCEDURE FOR INSTALLATION AND OPERATION OF PLATFORMS, FIXED AND MOBILE STRUCTURES, AND ARTIFICIAL ISLANDS

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.19(a). Section 250.19(a) provides as follows:

> *(a) The supervisor is authorized to approve the design, other features, and plan of installation of all platforms, fixed structures, and artificial islands as a condition of the granting of a right of use or easement under paragraph (a) or (b) of section 250.18 or authorized under any lease issued or maintained under the Act.*

Platforms, fixed structures and artificial islands are hereinafter referred to as structures. The operator shall be responsible for compliance with the requirements of this Order in the installation and operation of all platforms, fixed and mobile structures, and artificial islands, including all facilities installed on a structure whether or not operated or owned by the operator. The requirements of subparagraphs 2.A.(3), (4), (8), and (9) of this Order shall apply to all mobile drilling structures used to conduct drilling or workover operations on Federal leases in the Pacific Region.

Any departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. *The following requirements are applicable to all structures approved and installed subsequent to the effective date of this Order, and to all structures when structural and equipment modifications are to be made:*

   A. *General Design.* *The design of structures shall include consideration of such factors as water depth, surface* *and subsurface soil conditions, wave and current forces, wind forces, total equipment weight, seismic forces, and other pertinent geological, geographical, environmental, and operational conditions. At the discretion of the Supervisor, the operator may first obtain preliminary approval of the design of the structure by submitting general specifications which will demonstrate that a satisfactory installation can be designed. The operator may then proceed with detailed design work for final approval which shall comply with the requirements listed below.*

B. Application. The operator shall submit in duplicate, for approval, the following to the appropriate District Office.

(1) Design Features. Information relative to design features on a plat or plats showing the structure dimensions, plan and two elevations, number and location of well slots, and water depth. In addition, the plat shall include:

(a) Nominal size and thickness range of piling.

(b) Nominal size and thickness range of jacket column leg.

(c) Nominal size and thickness range of deck column leg.

(d) Design piling penetration.

(e) Maximum bearing and lateral load per pile in tons.

(f) Identification data which shall be the OCS lease number, the structure designation, and the name of the lease operator.

(g) The following certification signed and dated with the title of the company representative:

"______________ certifies that this structure has been certified by a registered professional engineer and that the structure is designed to withstand the specific stresses and conditions outlined in subparagraph 1.A. and as detailed in subparagraph 1.B.(2)(g) of OCS Order No. 8 and will be constructed, operated, and maintained as described in the application, and any approved modification thereto. Certified plans are on file at __________________."

(2) *Other Features.* Information relative to other features including the following:

(a) Primary use intended, including drilling and/or production of oil and gas.

(b) Personnel and personnel transfer facilities, including living quarters, boat landings, and heliport.

(c) Type of deck, such as steel sheeting or open grating, and whether coated with protective material.

(d) Method of protection from corrosion.

(e) Production facilities including separators, treaters, storage tanks, compressors, line pumps, and metering devices, except that when initially designed and utilized for drilling, this information may be submitted prior to installation.

(f) Safety and pollution control equipment and features.

(g) The design paramters used and the maximum stresses for which designed in terms of the specific forces and conditions outlined in subparagraph 1.A. above.

(h) Other information when required.

C. *Certified Plan.* Detailed structural plans certified by a registered professional engineer shall be on file and maintained by the operator or his designee.

2. *Safety and Pollution Control Equipment and Procedures.*

A. The following requirements shall apply to all structures. Subparagraphs 2.A.(3), (4), (8), and (9) shall also apply to mobile drilling structures. Operators of existing structures, including mobile drilling structures, shall have 90 days from the date of this Order in which to comply with the requirements of subparagraphs 2.A.(1) through (8) and one year in which to comply with subparagraph 2.A.(9).

(1) The following devices shall be installed and maintained in an operating condition on all pressurized vessels and water separation facilities when such vessels and separation facilities are in service. The operator shall maintain records on the structure or facility showing the present status and past history of each such device including

dates and details of inspection, testing, repairing, adjustment, and reinstallation or replacement.

(a) All separators shall be equipped with high-low pressure shut-in sensors, low level shut-in controls, and a relief valve. High liquid level control devices shall be installed when the vessel can discharge to a gas vent line.

(b) All pressure surge tanks shall be equipped with a high and low pressure shut-in sensor, a high level shut-in control, gas vent line, and relief valve.

(c) Atmospheric surge tanks shall be equipped with a high level shut-in sensor.

(d) All other hydrocarbon handling pressure vessels shall be equipped with high-low pressure shut-in sensors, high-low level shut-in controls, and relief valves, unless they are determined by the Supervisor to be otherwise protected.

(e) Pilot-operated pressure relief valves shall be equipped to permit testing with an external pressure source. Spring-loaded pressure relief valves shall either be bench-tested or equipped to permit testing with an external pressure source. A relief valve shall be set no higher than the designed working pressure of the vessel. The high pressure shut-in sensor shall be set no higher than 5% below the rated or designed working pressure and the low pressure shut-in sensor shall be set no lower than 10% below the lowest pressure in the operating pressure range on all vessels with a rated or designed working pressure of more than 400 psi. On lower pressure vessels the above percentages shall be used as guidelines for sensor settings considering pressure and operating conditions involved; except that sensor settings shall not be within 5 psi of the rated or designed working pressure or the lowest pressure in the operating pressure range.

(f) *All pressure-operated sensors shall be equipped to permit testing with an external pressure source.*

(g) *All gas vent lines shall be equipped with a scrubber or similar separation equipment.*

(2) *The following devices shall be installed and maintained in an operating condition at all times when the affected well (or wells) is producing. The operator shall maintain records on the structure or facility showing the present status and past history of each such device, including dates and details of inspection, testing, repairing, adjustment, and reinstallation or replacement.*

(a) *All well head assemblies shall be equipped with an automatic fail-close valve. Automatic safety valves temporarily out of service shall be flagged.*

(b) *All flowlines from wellheads shall be equipped with high-low pressure sensors located close to the wellhead. The pressure sensors shall be set to activate the wellhead valve in the event of abnormal pressures in the flowline.*

(c) *All headers shall be equipped with check valves on the individual flowlines. The flowline and valves from each well located upstream of, and including, the header valves shall withstand the shut-in pressure of that well, unless protected by a relief valve with connections to bypass the header. If there is an inlet valve to a separator, the valve, flowline, and all equipment upstream of the valve shall also withstand shut-in wellhead pressure, unless protected by a relief valve with connections to bypass the header.*

(d) *All pneumatic, hydraulic, and other shut-in control lines shall be equipped with fusible material at strategic points.*

(e) *Remote shut-in controls shall be located on the helicopter deck and all exit stairway landings leading to the helicopter deck and to all boat landings. These controls shall be quick-operating devices.*

(f) *All pressure sensors shall be operated and tested for proper pressure settings monthly* *for at least four months. At such time as the monthly results are consistent, a quarterly test shall be required for at least one year. If these results are consistent, a longer period of time between testing may then be approved by the Supervisor. In the event any testing sequence reveals inconsistent results, the monthly testing sequence shall be reinstituted. Results of all tests shall be recorded and maintained on a structure in the field.*

(g) All automatic wellhead safety valves shall be tested for operation weekly. All automatic wellhead safety valves shall be tested for holding pressure monthly. If these results are consistent, a longer period of time between pressure tests, not to exceed quarterly, may then be approved by the Supervisor. In the event that any pressure testing sequence, exceeding monthly, reveals inconsistent results, the monthly testing sequence shall be reinstituted. Results of all tests shall be recorded and maintained on a structure in the field.

(h) Check valves shall be tested for holding pressure monthly for at least four months. At such time as the monthly results are satisfactory, a quarterly test shall be required for at least one year. If these results are consistent, a longer period of time between testing may then be approved by the Supervisor. In the event any testing sequence reveals inconsistent results, the monthly testing sequence shall be reinstituted. Results of all tests shall be recorded and maintained on a structure in the field.

(i) A complete testing and inspection of the safety system shall be witnessed by Geological Survey representatives at the time production is commenced. Thereafter, the operator shall arrange for a test every six months. The test shall be conducted when it can be witnessed by Geological Survey representatives.

(j) *A standard procedure for testing of safety equipment shall be prepared and posted in a prominent place on the platform.*

(3) *Curbs, gutters, and drains shall be constructed and maintained in good condition in all deck areas in a manner necessary to collect all contaminants, unless drip pans or equivalent are placed under equipment and piped to a sump which will automatically maintain the oil at a level sufficient to prevent discharge of oil into the ocean waters. Alternate methods to obtain the same results may be approved by the Supervisor. These systems shall not permit spilled oil to flow into the wellhead area.*

(4) *An auxiliary electrical power supply shall be installed to provide emergency power capable of operating all electrical equipment required to maintain safety of operation in the event the primary electrical power supply fails.*

(5) *The following requirements shall apply to the handling and disposal of all produced waste water discharged into the ocean waters overlying the submerged lands of the OCS. The disposal of waste water other than into these waters shall be approved by the Supervisor.*

(a) *Water discharged shall not create conditions which will adversely affect the public health or the use of the waters for the propagation of aquatic life, recreation, navigation, or other legitimate uses.*

(b) *Waste water disposal systems shall be designed and maintained to reduce the oil content of the disposed water to not more than fifty ppm. An effluent sampling station shall be located at a point prior to discharge into the receiving waters where a representative sample of the treated effluent can be obtained. On one day each month the effluent shall be sampled hourly for 8 hours and the following determinations shall be made on the composite sample: suspended solids, settleable solids, pH, total oil and grease content, and volume of sample obtained. Also the temperature of each hourly sample shall be recorded. All* *samples shall be taken and all analyses for oil and grease content shall be performed in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater", published by the American Public Health Association, Inc. The Supervisor may approve different methods for determination of oil and grease content if the method to be used is indicated to be reliable. A written report of the results shall be furnished to the Regional Office monthly. The report shall contain dates, time and location of sample, volumes of waste discharge on the date of sampling in barrels per day, and the results of the specific analysis and physical observations. A visual inspection of the appearance of the receiving waters in the discharge area shall be made daily and the results recorded and included in the monthly report.*

(6) A firefighting system shall be installed and maintained in an operating condition in accordance with the following:

(a) A fixed automatic water spray system shall be installed in all wellhead areas. These systems shall be installed in accordance with the current edition of National Fire Protection Association's Pamphlet No. 15.

(b) A firewater system of rigid pipe with fire hose stations shall be installed and may include a fixed water spray system. Such a system shall be installed in a manner necessary to provide needed protection in areas where production handling equipment is located. A firefighting system using chemicals may be considered for installation in certain areas in lieu of a firewater system in that area, if determined by the Supervisor to provide equivalent fire protection control.

(c) Pumps for the firewater systems shall be test-operated weekly. A record of the tests shall be maintained on a structure in the field and submitted semi-annually to the District Office. An alternate fuel or power source shall be installed to provide continued pump operation during platform shutdown unless an alternate firefighting system is provided.

(d) *Portable fire extinguishers shall be located in the living quarters and in other strategic areas.*

(e) *A diagram of the firefighting system showing the location of all equipment shall be posted in a prominent place on the structure and a copy submitted to the District Office.*

(7) *An automatic gas detector and alarm system shall be installed and maintained in an operating condition in accordance with the following:*

(a) *Gas detection systems shall be installed in all enclosed areas containing gas handling facilities or equipment and in other enclosed areas which are classified as hazardous areas as defined in API RP 500 A and B and the current edition of the National Electric Code.*

(b) *All gas detection systems shall be capable of continuously monitoring for the presence of combustible gas in the areas in which the detection devices are located.*

(c) *The central control shall be capable of giving an alarm at a point not higher than 60 percent of the lower explosive limit.*

(d) *The central control shall automatically activate shut-in sequences and emergency equipment at a point not higher than 90% of the lower explosive limit.*

(e) *An application for the installation and maintenance of any gas detection system shall be filed with the appropriate District Office for approval. The application shall include the following:*

(i) *Type, location, and number of detection or sampling heads.*

(ii) *Cycling, non-cycling, and frequency information.*

(iii) *Type and kind of alarm including emergency equipment to be activated.*

(iv) *Method used for detection of combustible gas.*

(v) *Method and frequency of calibration.*

(vi) *A diagram of the gas detection system.*

(vii) *Other pertinent information.*

(f) *A diagram of the gas detection system showing the location of all gas detection points shall be posted in a prominent place on the structure.*

(8) *The following requirements shall be applicable to all electrical equipment and systems installed:*

(a) *All gas and gasoline engines shall be equipped with low-tension ignition systems containing rigid connections and shielded wiring which shall prevent the release of sufficient electrical energy under normal or abnormal conditions to cause ignition of a combustible mixture.*

(b) *All electrical generators, motors, and lighting systems shall be installed, protected, and maintained in accordance with the current edition of the electrical code of the adjacent State, National Electric Code, and API RP 500 A and B, as appropriate. On mobile drilling structures, certificated by the Coast Guard, this equipment shall be installed, protected, and maintained in accordance with the applicable provisions of 46 CFR 110 through 113, inclusive.*

(c) *Marine-armored cable or metal-clad cable may be substituted for wire in conduit in any area.*

(9) *Sewage disposal systems shall be installed and maintained in satisfactory operating condition in all cases where sewage is discharged into the ocean waters. Sewage is defined as human body wastes and the wastes from toilets and other receptacles intended to receive or retain body wastes. Following sewage treatment, the effluent shall contain 50 ppm or less of biochemical oxygen demand (BOD), 150 ppm or less of suspended solids, and shall have a minimum chlorine residual*

of 1.0 mg/liter after a minimum retention time of fifteen minutes. Sewage treatment records shall be maintained and made available for inspection upon request. The records shall reflect the results of monthly tests. These tests shall include determination of BOD, suspended solids, and chlorine residual.

B. Welding Practices and Procedures. The following requirements shall apply to all structures, including mobile drilling structures, as applicable. The period of time during which these requirements are considered applicable to mobile drilling structures is the interval from the drilling out of the shoe of the conductor casing until the BOP stack and the marine riser are pulled in the process of final abandonment or suspension. For the purpose of this Order the term "welding and burning" is defined to include arc or acetylene welding and arc or acetylene cutting.

(1) All welding and burning shall be minimized.

(2) Such welding or burning as is necessary, on a structure, shall adhere to the following practices:

(a) Welding or burning on the structure should be done in an approved, properly functioning welding room; however, all welding and burning that is required but that cannot be prudently done in the welding room, shall be performed in compliance with the procedures outlined below.

(b) Prior to the commencement of any burning or welding operations, on a structure, the senior person in charge at the installation shall personally inspect the area in which the work is to be done. After this person has determined that it is safe to proceed, he shall issue a written authorization for the work. If both drilling and production operations are being conducted on the structure, the senior drilling man and the senior production man shall make this inspection and both shall sign it.

(c) A copy of each welding or burning authorization shall be maintained on the structure for a period of one year. These authorizations shall be made available, for inspection, to any authorized representative of the Geological Survey.

(d) During all welding or burning operations, one or more persons as necessary shall be designated as a "fire watch". Persons assigned to "fire watch" shall have no other duties while so assigned.

(e) The "fire watch" shall wear an item of distinctive clothing (vest or coat) for identification purposes and shall have in his immediate possession a portable gas detector and a portable fire extinguisher.

(f) If welding or burning must be done on containers, tanks, or other vessels which have contained a flammable substance, these objects shall be thoroughly cleaned and rendered free of such flammable substance before the work begins.

(g) If welding or burning must be done on in-service or connected-up piping, that section of pipe shall be isolated by tightly closed valves, blind flanges, or other suitable means, bled to atmospheric pressure, and thoroughly purged and cleaned to render it free of any flammable substance.

(h) If welding or burning must be done in confined spaces, the space shall be adequately vented and a continuous source of fresh air shall be supplied while work is in progress. If the fresh air is supplied by blowers, they shall be so positioned that the intakes will not pick up exhausted gases, fumes, or vapors.

(i) If any welding or burning is done on bulkheads, decks, or overheads, the adjacent, overlying, or underlying spaces shall be examined to determine that it is safe for the work to proceed. If deemed advisable, a second "fire watch" shall be employed in the contiguous area.

(j) *If any welding or burning must be done on structural members, it shall be determined by a competent authority that such welding or burning does not endanger the integrity of the structure.*

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G Wayland

Russell G. Wayland
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
BRANCH OF OIL AND GAS OPERATIONS
PACIFIC REGION

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

APPROVAL PROCEDURE FOR PIPELINES

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.19(b). Section 250.19(b) provides as follows:

> *(b) The supervisor is authorized to approve the design, other features, and plan of installation of all pipelines for which a right of use or easement has been granted under paragraph (c) of section 250.18 or authorized under any lease issued or maintained under the act, including those portions of such lines which extend onto or traverse areas other than the Outer Continental Shelf.*

The operator shall comply with the following requirements. Platforms, fixed structures, and artificial islands are hereinafter referred to as structures. This Order does not apply to common carrier pipelines except as to that portion connected to or crossing a structure. Any departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. General Design. All pipelines shall be designed and maintained in accordance with the following:

A. The operator shall be responsible for the installation of the following control devices on all oil and gas pipelines connected to a structure, including pipelines which are not operated or owned by the operator. Operators of structures installed prior to the effective date of this Order shall comply with the requirements of subparagraphs (1) through (6) within 6 months of the effective date of this Order. The operator shall maintain records on the structure or facility showing the present status and past history of each device, including dates and details of inspection, testing, repairing, adjustment, reinstallation or replacement.

(1) All oil and gas pipelines leaving a structure receiving production from the structure shall be equipped with a high-low pressure sensor to shut in the wells on the structure.

(2) All oil and gas pipelines delivering production to either offshore or onshore production facilities, or both, shall be equipped with an automatic shut-in valve, at or near the receiving facility, connected to an automatic and a remote shut-in system.

(3) All oil and gas pipelines coming onto a structure or delivering production to an onshore facility shall be equipped with a check valve or a quick-operating manual valve, as approved by the Supervisor, at or near the structure or facility to control backflow.

(4) All oil and gas pipelines crossing a structure which do not deliver production to the structure, but which may or may not receive production from the structure, shall be equipped with sensors to activate an automatic shut-in valve to be located in the upstream portion of the pipeline at or near the structure to avoid uncontrolled flow at the structure. This automatic shut-in valve shall be connected to either the structure automatic and remote shut-in system or to an independent remote shut-in system.

(5) All oil pumps and gas compressors shall be equipped with high-low pressure shut-in devices.

(6) All oil pipelines shall have a metering system to provide a continuous volumetric comparison of input to the line at the structure, or structures, with deliveries onshore. The system shall include an alarm system and shall be of adequate sensitivity to detect significant variations between input and discharge volumes. In lieu of the foregoing, any system capable of detecting small leaks in the pipeline may be substituted with the approval of the Supervisor.

B. All oil and gas and other pipelines shall be protected from loss of metal that would endanger the strength and safety of the lines by methods such as protective coatings or cathodic protection.

C. All oil and gas and other pipelines shall be installed and maintained to be compatible with trawling operations and other uses.

D. All oil and gas and other pipelines shall be hydrostatically tested to 1.25 times the designed working pressure for a minimum of 2 hours prior to placing the line in service.

E. All oil and gas pipelines shall be maintained in good operating condition at all times and the ocean surface above the pipeline shall be inspected a minimum of once each week for indication of leakage using aircraft, floating equipment or other means. Records of these inspections including the date, methods, and results of each inspection shall be maintained by the operator and submitted to the District Engineer annually by April 1. The operator shall immediately notify the District Engineer of any pipeline leak and within one week shall submit a report to him with respect to the cause, effect, and remedial action taken.

F. All oil and gas and other pipelines shall be designed and maintained for protection against water currents, storm scouring, soft bottoms, and other environmental factors.

G. An external inspection of all pipelines by side scan sonar or other means acceptable to the Supervisor shall be made at least once each year to identify all exposed portions of pipelines. All exposed portions of pipelines shall then be inspected in detail by photographic or other means acceptable to the Supervisor to determine if any hazards exist to the line or other users of the area. If a hazard is found to exist, appropriate corrective action shall be taken. Records of these inspections including the date, methods, and results of each inspection, shall be maintained by the operator and submitted to the District Engineer when the records become available.

2. Application. The operator shall submit in duplicate the following to the District Engineer for forwarding and approval by the Supervisor:

A. Drawing on a plat or plats showing the major features and other pertinent data including: (1) water depth, (2) route, (3) location, (4) length, (5) connecting facilities, (6) size, and (7) burial depth, if buried.

B. A schematic drawing showing the location of the following pipeline safety equipment and the manner in which the equipment functions: (1) high-low pressure sensors, (2) automatic shut-in valves, (3) check valves, and (4) the volumetric metering system.

C. General information concerning the pipeline including the following:

(1) Product or products to be transported by the pipeline.

(2) Size, weight and grade of the pipe.

(3) Length of line.

(4) Maximum water depth.

(5) Type or types of corrosion protection.

(6) Description of protective coating.

(7) Bulk specific gravity of line (with the line empty).

(8) Anticipated gravity or density of the product or products.

(9) Design working pressure and capacity.

(10) Maximum working pressure and capacity.

(11) Hydrostatic pressure and hold time to which the line will be tested after installation.

(12) Size and location of pumps and prime movers.

(13) Any other pertinent information as the Supervisor may prescribe.

3. Completion Report. The operator shall notify the District Engineer when installation of the pipeline is completed and submit a drawing, in duplicate, showing the location of the line as installed, accompanied by all hydrostatic test data, including procedure, test pressure, hold time, and results.

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

OCS Order No. 10
June 1, 1971

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
BRANCH OF OIL AND GAS OPERATIONS
PACIFIC REGION

NOTICE TO PERMITTEES OF TWIN CORE HOLE PERMITS IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

DRILLING OF TWIN CORE HOLES

The Secretary of the Interior on November 3, 1965, approved the drilling of core holes on unleased lands of the Outer Continental Shelf off the coast of Southern California (30 Federal Register No. 218, Nov. 10, 1965). Authority was delegated to the Regional Oil and Gas Supervisor of the U. S. Geological Survey to approve the drilling of such wells provided (1) the core hole to be drilled is located within 100 feet of a well heretofore drilled under a State permit, or such greater distance from such a well as the Supervisor may prescribe where the prior drilled well is less than three geographical miles from the coastline, (2) the maximum depth to which a core hole may be drilled shall be the depth of the prior drilled well, (3) the approvals to drill core holes granted by the Supervisor shall be conditioned upon compliance with the regulations in 30 CFR Part 250, and such other reasonable requirements as he may prescribe, and (4) no approval to drill shall be granted until the applicant has posted an acceptable corporate surety bond in the amount prescribed in 43 CFR 3304.1, conditioned on compliance with all the requirements set forth in the permits to drill granted by the Supervisor.

In addition to the above, the permittee shall comply with the following requirements:

1. *OCS Orders No. 1, 2, 3, 7, and 8 are hereby made applicable to core drilling operations.*

2. *An application for a general permit to conduct core drilling shall have been filed for approval prior to the filing of any applications to drill specific core holes.*

3. *A $300,000 corporate surety bond (Form 3380-3) covering Pacific Coast OCS operations shall have been filed.*

4. *Each application to drill a core hole (Form 9-331C in triplicate) shall be held in an open file in the Supervisor's office for 15 days after filing before approval may be granted. Only the application shall be considered public information.*

5. *The permittee shall: (a) obtain or have a geological survey blanket permit from the State to drill core holes within State waters, (b) obtain appropriate permission from the Army Corps of Engineers for the location of drilling ships (as provided in the Secretary of the Interior's Notice in 18 FR No. 186, Sept. 23, 1953).*

6. *All core hole locations shall be described by the Lambert Coordinate System for reference purposes applicable to the location in which it falls.*

7. *In each application to drill a twin core hole, the original State-permitted core hole shall be identified.*

8. *The permittee shall file a statement as to the exact location of the surface of the approved core hole and certify that it is within 100 feet of the original core hole at such time as drilling commences.*

9. *No directionally drilled core holes will be permitted.*

10. *Mud log and gas detector equipment shall be in operation while drilling below the shoe of the surface casing on twinned holes and below the shoe of the conductor casing on core holes offsetting the three-mile line not being drilled as a twin.*

11. *No down-hole formation fluid sampling equipment shall be operated at any time.*

12. *Conventional coring will be permitted either to total approved depth or such lesser depth as prescribed by the Supervisor provided the permittee of the original core hole being twinned has not filed an affidavit with the Supervisor stating that no conventional coring had been conducted in the original core hole. Sidewall sample coring may be conducted in that part of the hole in which an electric log has been run. Upon completion of operations the permittee shall file with the Supervisor a duly attested duplicate copy of the contractor's original log (tour sheet).*

13. *The permittee shall advise the District Engineer, Geological Survey, at least 48 hours prior to the drilling and reaching of the approved total depth. The "measuring out" of drill pipe at total depth will be witnessed by the District Engineer or his representative.*

14. *The permittee shall not commence any abandonment operations prior to obtaining written approval from the District Engineer, Geological Survey. Abandonment of the core hole and clearing of the location of all obstructions on the ocean floor shall be witnessed by a representative of the Geological Survey.*

15. *Such other requirements as shall be prescribed in the general permit or the specific approved core hole application, or at any time such additional requirements are deemed necessary by the Supervisor or his representative.*

D.W. Solanas

D. W. Solanas
Supervisor

Approved: June 1, 1971

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
PACIFIC AREA

OCS ORDER NO. 11

Effective May 1, 1975

OIL AND GAS PRODUCTION RATES, PREVENTION OF WASTE, AND PROTECTION OF CORRELATIVE RIGHTS

This Order is established pursuant to the authority prescribed in 30 CFR 250.1, 30 CFR 250.11, and in accordance with all other applicable provisions of 30 CFR Part 250, and the Notice appearing in the Federal Register, dated December 5, 1970 (35 FR 18559), to provide for the prevention of waste and conservation of the natural resources of the Outer Continental Shelf, and the protection of correlative rights therein. This Order shall be applicable to all oil and gas wells on Federal leases in the Outer Continental Shelf of the Pacific Area. All departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b). References in this Order to approvals, determinations, and requirements for submitting of information or applications for approval are to those granted, made, or required by the Oil and Gas Supervisor or his delegated representative.

1. Definition of Terms. As used in this Order, the following terms shall have the meanings indicated:

A. Waste of Oil and Gas. The definition of waste appearing in 30 CFR 250.2(h) shall apply, and includes the failure to timely initiate enhanced recovery operations where such methods would result in an increased ultimate recovery of oil or gas under sound engineering and economic principles. Enhanced recovery operations refers to pressure maintenance operations, secondary and tertiary recovery, cycling, and similar recovery operations which alter the natural forces in a reservoir to increase the ultimate recovery of oil or gas.

B. Correlative Rights. The opportunity afforded each lessee or operator to produce without waste his just and equitable share of oil and gas from a common source of supply.

C. Maximum Efficient Rate (MER). The maximum sustainable daily oil or gas withdrawal rate from a reservoir which will permit economic development and depletion of that reservoir without detriment to ultimate recovery.

D. Maximum Production Rate (MPR). The approved maximum daily rate at which oil may be produced from a specified oil well completion or the maximum approved daily rate at which gas may be produced from a specified gas well completion.

E. Interested Party. The Operators and lessees, as defined in 30 CFR 250.2(f) and (g), of the lease or leases involved in any proceeding initiated under this Order.

F. Reservoir. An oil or gas accumulation which is separated from and not in oil or gas communication with any other such accumulation.

G. Competitive Reservoir. A reservoir as defined herein containing one or more producible or producing well completions on each of two or more leases, or portions thereof, in which the lease or operating interests are not the same.

H. Property Line. A boundary dividing leases, or portions thereof, in which the lease or operating interest is not the same. The boundaries of federally approved unit areas shall be considered property lines. The boundaries dividing leased and unleased acreage shall be considered property lines for the purpose of this Order.

I. Oil Reservoir. A reservoir that contains hydrocarbons predominantly in a liquid (single-phase) state.

J. Oil Well Completion. A well completed in an oil reservoir or in the oil accumulation of an oil reservoir with an associated gas cap.

K. *Gas Reservoir. A reservoir that contains hydrocarbons predominantly in a gaseous (single-phase) state.*

L. *Gas Well Completion. A well completed in a gas reservoir or in the gas cap of an oil reservoir with an associated gas cap.*

M. *Oil Reservoir with an Associated Gas Cap. A reservoir that contains hydrocarbons in both a liquid and a gaseous state (two-phase).*

N. *Producible Well Completion. A well which is physically capable of production and which is shut-in at the wellhead or at the surface, but not necessarily connected to production facilities, and from which the operator plans future production.*

2. *Classification of Reservoirs.*

A. *Initial Classification. Each producing reservoir shall be classified by the operator, subject to approval by the Supervisor, as an oil reservoir, an oil reservoir with an associated gas cap, or a gas reservoir.*

(1) *The initial classification of each reservoir from which production is commenced subsequent to the date of this Order shall be submitted for approval with the initial submittal of MER data for the reservoir.*

(2) *Each reservoir from which production commenced on or prior to the date of this Order shall be classified by the operator, based on existing reservoir conditions. Such classification shall be determined and submitted to the Supervisor within six (6) months of the date of this Order.*

B. *Reclassification. A reservoir may be reclassified by the Supervisor, on his own initiative or upon application of an operator, during its productive life when information becomes available showing that such reclassification is warranted.*

3. *Oil and Gas Production Rates.*

A. *Maximum Efficient Rate (MER). The operator shall propose a maximum efficient rate (MER) for each producing reservoir based on sound engineering and economic principles. When approved at the proposed or other rate, such rate shall not be exceeded, except as provided in paragraph 4 of this Order.*

(1) *Submittal of Initial MER*. Within 45 days after the date of first production or such longer period as may be approved, the operator shall submit a Request for Reservoir MER (Form 9-1866) with appropriate supporting information. Within six months after the date of this Order, the operator shall submit a Request for Reservoir MER (Form 9-1866) with appropriate supporting information for each reservoir from which production commenced prior to the date of this Order.

(2) *Revision of MER*. The operator may request a revision of an MER by submitting the proposed revision to the Supervisor on a Request for Reservoir MER (Form 9-1866) with appropriate supporting information. The operator shall obtain approval to produce at test rates which exceed an approved MER when such testing is necessary to substantiate an increase in the MER.

(3) *Review of MER*. The MER for each reservoir will be reviewed by the operator annually, or at such other required or approved interval of time. The results of the review, with all current supporting information shall be submitted on a Request for Reservoir MER (Form 9-1866).

(4) *Effective Date of MER*. The effective date of an MER, or revision thereof, will be determined by the Supervisor and shown on a Request for Reservoir MER (Form 9-1866) when the MER is approved. The effective date for an initial MER shall be the first day following the completion of an approved testing period. The effective date for a revised MER shall be the first day following the completion of an approved testing period, or if testing is not conducted, the date the revision is approved.

B. *Maximum Production Rate (MPR)*. The operator shall propose a maximum production rate (MPR) for each producing well completion in a reservoir together with full information on the method used in its determination. When an MPR has been approved for a well completion, that rate shall not be exceeded, except as provided in paragraph 4 of this Order. The MPR shall be based on well tests and any limitations imposed by (1) well tubing, safety equipment, artificial lift equipment, surface back pressure, and equipment capacity; (2) sand producing problems, (3) producing gas-oil and water-oil ratios; (4) relative structural position of the well *with respect to gas-oil or water-oil contacts; (5) position of perforated interval within total production zone; and (6) prudent operating practices. The MPR established for each well completion shall not exceed 110 percent of the rate demonstrated by a well test unless justified by supporting information.*

(1) Submittal of Initial MPR. Within six months after the date of this Order, the operator shall submit a Request for Well Maximum Production Rate (MPR) (Form 9-1867), with the results of the potential test on a Well Potential Test Report (Form 9-1868). Thereafter, the operator shall have 30 days from the date of first continuous production within which to conduct a potential test, as specified under subparagraphs 5.B and 6.B of this Order, on all new and reworked well completions. Within 15 days after the date of the potential test, the operator shall submit a proposed MPR for the individual well completion on a Request for Well Maximum Production Rate (MPR) (Form 9-1867), with the results of the potential test on a Well Potential Test Report (Form 9-1868). Extension of the 30-day test period may be granted. The effective date for any approved initial MPR shall be the first day following the test period. During the 30-day period allowed for testing, or any approved extensions thereof, the operator may produce a new or reworked well completion at rates necessary to establish the MPR. The operator shall report the total production obtained during the test period and approved extensions thereof, on the Well Potential Test Report (Form 9-1868).

(2) Revision of MPR Increase. If necessary to test a well completion at rates above the approved MPR to determine whether the MPR should be increased, notification of intent to test the well at such higher rates, not to exceed a stated maximum rate during a specified test period, shall be filed with the Supervisor. Such tests may commence on the day following the date of filing notification, unless otherwise ordered by the Supervisor. If an operator determines that the MPR should be increased he shall submit, within 15 days after the specified test period, a proposed increased MPR on a Request

for Well Maximum Production Rate (MPR) (Form 9-1867), and any other available data to support the requested revision, including the results of the potential test and the total production obtained during the test period on a Well Potential Test Report (Form 9-1868). Prior to approval of the proposed increased MPR, the operator may produce the well completion at a rate not to exceed the proposed increased MPR of the well. The effective date for any approved increased MPR shall be the first day following the test period. If testing rates or increased MPR rates result in production from the reservoir in excess of the approved MER, this excess production shall be balanced by underproduction from the reservoir under the provisions of subparagraph 4.B of this Order.

(3) Revision of MPR Decrease. When the quarterly test rate for an oil well completion or the semi-annual test rate for a gas well completion required under subparagraphs 5.C and 6.C of this Order is less than 90 percent of the existing approved MPR for the well, a new reduced MPR will be established automatically for that well completion equal to 110 percent of the test rate submitted. The effective date for the new MPR for such well completion shall be the first day of the quarter following the required date of submittal of periodic well-test results under subparagraphs 5.C and 6.C of this Order. Also, the operator may notify the Supervisor on a Request for Well Maximum Production Rate (MPR) (Form 9-1867) of, or the Supervisor may require, a downward revision of a well MPR at any time when the well is no longer capable of producing its approved MPR on a sustained basis. The effective date for such reduced MPR for a well completion shall be the first day of the month following the date of notification.

(4) Continuation of MPR. If submittal of the results of a quarterly well test for an oil completion or a semi-annual well test for a gas well completion, as provided for in subparagraphs 5.C and 6.C of this Order, cannot be timely, continuation of production under the last approved MPR for the well may be authorized, provided an extension of time in which to submit the test results is requested and approved in advance.

(5) *Cancellation of MPR. When a well completion ceases to produce, is shut-in pending workover, or any other condition exists which causes the assigned MPR to be no longer appropriate, the operator shall notify the Supervisor accordingly on a Request for Well Maximum Production Rate (MPR) (Form 9-1867), indicating the date of last production from the well, and the MPR will be canceled. Reporting of temporary shut-ins by the operator for well maintenance, safety conditions, or other normal operating conditions is not required, except as is necessary for completion of the Monthly Report of Operations (Form 9-152).*

C. *MER and MPR Relationship. The withdrawal rate from a reservoir shall not exceed the approved MER and may be produced from any combination of well completions subject to any limitations imposed by the MPR established for each well completion. The rate of production from the reservoir shall not exceed the MER although the summation of individual well MPR's may be greater than the MER.*

4. *Balancing of Production.*

A. *Production Variances. Temporary well production rates, resulting from normal variations and fluctuations exceeding a well MPR or reservoir MER shall not be considered a violation of this Order, and such production may be sold or transferred pursuant to paragraph 8 of this Order. However, when normal variations and fluctuations result in production in excess of a reservoir MER, any operator who is overproduced shall balance such production in accordance with subparagraph 4.B below. Such operator shall advise the Supervisor of the amount of such excess production from the reservoir for the month at the same time as Form 9-152 is filed for that month.*

B. *Balancing Periods. As of the first day of the month following the month in which this Order becomes effective, all reservoirs shall be considered in balance. Balancing periods for overproduction of a reservoir MER shall end on January 1, April 1, July 1, and October 1 of each year. If a reservoir* *is produced at a rate in excess of the MER for any month, the operator who is overproduced shall take steps to balance production during the next succeeding month. In any event, all overproduction shall be balanced by the end of the next succeeding quarter following the quarter in which the overproduction occurred. The operator shall notify the Supervisor at the end of the month in which he has balanced the production from an overproduced reservoir.*

C. *Shut-in for Overproduction. Any operator in an overproduction status in any reservoir for two successive quarters which has not been brought into balance within the balancing period shall be shut-in from that reservoir until the actual production equals that which would have occurred under the approved MER.*

D. *Temporary Shut-in. If, as the result of storm, hurricanes, emergencies, or other conditions peculiar to offshore operations, an operator is forced to curtail or shut-in production from a reservoir, the Supervisor may, on request, approve makeup of all or part of this production loss.*

5. *Oil Well Testing Procedures.*

A. *General. Tests shall be conducted for not less than four consecutive hours. Immediately prior to the 4-hour test period, the well completion shall have produced under stabilized conditions for a period of not less than six consecutive hours. The 6-hour pretest period shall not begin until after recovery of a volume of fluid equivalent to the amount of fluids introduced into the formation for any purpose. Measured gas volumes shall be adjusted to the standard conditions of the 15.025 psia and 60^{o} F. for all tests. When orifice meters are used, a specific gravity shall be obtained or estimated for the gas and a specific gravity correction factor applied to the orifice coefficient. The Supervisor may require a prolonged test or retest of a well completion if such test is determined to be necessary for the establishment of a well MPR or a reservoir MER. The Supervisor may approve test periods of less than four hours and pretest stabilization periods of less than six hours for well completions, provided that test reliability can be demonstrated under such procedures.*

B. *Potential Test.* Test data to establish or to increase an oil well MPR shall be submitted on a Well Potential Test Report (Form 9-1868). The total production obtained from all tests during the test period shall be reported on such form.

C. *Quarterly Test.* Tests shall be conducted on each producing oil well completion quarterly, and test results shall be submitted on a Quarterly Oil Well Test Report (Form 9-1869). Testing periods and submittal dates shall be as follows:

Testing Period	Latest Date for Submittal of Test Results	For Quarter Beginning
September 11 - December 10	December 10	January 1
December 11 - March 10	March 10	April 1
March 11 - June 10	June 10	July 1
June 11 - September 10	September 10	October 1

There shall be a minimum of 45 days between quarterly tests for an oil well completion.

6. *Gas Well Testing Procedures.*

A. *General.* Testing Procedures for gas well completions shall be the same as those specified for oil well completions in subparagraph 5.A except for the initial test which shall be a multi-point back-pressure test as described in paragraph 6.D.

B. *Potential Test.* Test data to establish or to increase a gas well MPR shall be submitted on a Well Potential Test Report (Form 9-1868).

C. *Semi-annual Test.* Tests shall be conducted on each producing gas well completion semi-annually, and test results shall be submitted on a Semi-annual Gas Well Test Report (Form 9-1870). Testing periods and submittal dates shall be as follows:

Testing Period	For Submittal of Test Results	For Semi-Annual Period Beginning
June 11 - December 10	December 10	January 1
December 11 - June 10	June 10	July 1

There shall be a minimum of 90 days between semi-annual tests for a gas well completion.

D. Back-Pressure Tests. A multi-point back-pressure test to determine the theoretical open-flow potential of gas wells shall be conducted within thirty days after connection to a pipeline. If bottom-hole pressures are not measured, such pressures shall be calculated from surface pressures using the method, or other similar method, found in the Interstate Oil Compact Commission (IOCC) Manual of Back-Pressure Testing of gas wells. The results of all back-pressure tests conducted by the operator shall be filed with the Supervisor, including all basic data used in determining the test results. The Supervisor may waive this requirement if multi-point back-pressure test information has previously been obtained on a representative number of wells in a reservoir.

7. Witnessing Well Tests. The Supervisor may have a representative witness any potential or periodic well tests on oil and gas well completions. Upon request, an operator shall notify the appropriate District office of the time and date of well tests.

8. Sale or Transfer of Production. Oil and gas produced pursuant to the provisions of this Order, including test production, may be sold to purchasers or transferred as production authorized for disposal hereunder.

9. Bottom-Hole Pressure Tests. Static bottom-hole pressure test shall be conducted annually on sufficient key wells to establish an average reservoir pressure in each producing reservoir unless a different frequency is approved. The operator may be required to test specific wells. Results of bottom-hole pressure tests shall be submitted within 60 days after the date of the test.

10. Flaring and Venting of Gas. Oil- and gas-well gas shall not be flared or vented, except as provided herein.

A. Small-Volume or Short-Term Flaring or Venting. Oil- and gas-well gas may be flared or vented in small volumes or temporarily without the approval of the Supervisor in the following situations:

(1) Gas Vapors. When gas vapors are released from storage and other low pressure production vessels if such gas vapors cannot be economically recovered or retained.

(2) *Emergencies*. *During temporary emergency situations, such as compressor or other equipment failure, or the relief of abnormal system pressures.*

(3) *Well Purging and Evaluation Tests*. *During the unloading or cleaning up of a well and during drillstem, producing, or other well evaluation tests not exceeding a period of 24 hours.*

B. *Approval for Routine or Special Well Tests*. *Oil- and gas-well gas may be flared or vented during routine and special well tests, other than those described in paragraph A above, only after approval of the Supervisor.*

C. *Gas-Well Gas*. *Except as provided in A and B above, gas-well gas shall not be flared or vented.*

D. *Oil-Well Gas*. *Except as provided in A and B above, oil-well gas shall not be flared or vented unless approved by the Supervisor. The Supervisor may approve an application for flaring or venting of oil-well gas for periods not exceeding one year if (1) the operator has initiated positive action which will eliminate flaring or venting, or (2) the operator has submitted an evaluation supported by engineering, geologic, and economic data indicating that rejection of an application to flare or vent the gas will result in an ultimate greater loss of equivalent total energy than could be recovered for beneficial use from the lease if flaring or venting were allowed.*

E. *Content of Application*. *Applications under paragraph D above for existing operations, as of the date of this Notice, shall be filed within three months from the effective date of this Order. Applications under paragraph D(2) above shall include all appropriate engineering, geologic, and economic data in an evaluation showing that absence of approval to flare or vent the gas will result in premature abandonment of oil and gas production or curtailment of lease development. Applications shall include an estimate of the amount and value of the oil and gas reserves that* would not be recovered if the application to flare or vent were rejected and an estimate of the total amount of oil to be recovered and associated gas that would be flared or vented if the application were approved.

11. Disposition of Gas. The disposition of all gas produced from each lease shall be reported monthly on, or attached to, Form 9-152. The report shall be submitted in the following manner:

	Oil-Well Gas (MCF)	Gas-Well Gas (MCF)
Sales		
Fuel		
*Injected		
Flared		
Vented		
Other (Specify)		
Total		

*Gas produced from the lease and injected on or off the lease.

12. Multiple and Selective Completions.

A. Number of Completions. A well bore may contain any number of producible completions when justified and approved.

B. Numbering Well Completions. Well completions made after the date of this Order shall be designated using numerical and alphabetical nomenclature. Once designated as a reservoir, or commingled reservoirs completion, the well completion number shall not change. Appendix A contains a detailed explanation of procedures for naming well completions.

C. Packer Tests. Multiple and selective completions shall be equipped to isolate the respective producing reservoirs. A packer test or other appropriate reservoir isolation test shall be conducted prior to or immediately after initiating production and annually thereafter on all multiply completed wells. Should the reservoirs in any multiply completed well become intercommunicative the operator shall make repairs and again conduct reservoir isolation tests unless some other operational procedure is approved. The results of all tests shall be submitted on a Packer Test (Form 9-1871) within 30 days after the date of the test.

D. *Selective Completions.* Completion equipment may be installed to permit selective reservoir isolation or exposure in a well bore through wireline or other operations. All selective completions shall be designated in accordance with subparagraph 12.B when the application for approval of such completions is filed.

E. *Commingling.* Commingling of production from two or more separate reservoirs within a common well bore may be permitted if it is determined that, collectively, the ultimate recovery will not be decreased. An application to commingle hydrocarbons from multiple reservoirs within a common well bore shall be submitted for approval and shall include reservoir engineering data, and a schematic diagram of well equipment. For all competitive reservoirs, notice of the application shall be sent by the applicant to all other operators of interest in the reservoirs prior to submitting the application to the Supervisor. The application shall specify the well completion number to be used for subsequent reporting purposes.

13. *Gas-Cap Well Completions.* All existing and future wells completed in the gas cap of a reservoir which has been classified and approved as an associated oil reservoir shall be shut-in until such time as the oil is depleted or the reservoir is reclassified as a gas reservoir; provided, however, that production from such wells may be approved when (1) it can be shown that such gas-cap production would not lead to waste of oil and gas, or (2) when necessary to protect correlative rights unless it can be shown that this production will lead to waste of oil and gas.

14. *Location of Wells.*

A. *General.* The location and spacing of all exploratory and development wells shall be in accordance with approved programs and plans required in 30 CFR 250.17 and 250.34. Such location and spacing shall be determined independently for each lease or reservoir in a manner which will locate wells in the optimum structural position for the most effective production of reservoir fluids and to avoid the drilling of unnecessary wells.

B. Distance from Property Line. An operator may drill exploratory or development wells at any location on a lease in accordance with approved plans; provided that no well drilled and completed after the date of this Order in which the completed interval is less than 200 feet from a property line shall be produced unless approved by the Supervisor. An operator requesting approval to produce a well in which the completed interval is located closer than 200 feet from a property line shall furnish the Supervisor with letters expressing acceptance or objection from operators of offset properties.

15. Enhanced Oil and Gas Recovery Operations. Operators shall timely initiate enhanced oil and gas recovery operations for all competitive and noncompetitive reservoirs where such operations would result in an increased ultimate recovery of oil or gas under sound engineering and economic principles. A plan for such operations shall be submitted with the results of the annual MER review as required in paragraph 3A(3) of this Order.

16. Competitive Reservoir Operations. Development and production operations in a competitive reservoir may be required to be conducted under either pooling and drilling agreements or unitization agreements when the Conservation Manager determines, pursuant to 30 CFR 250.50 and delegated authority, that such agreements are practicable and necessary or advisable and in the interest of conservation.

A. Competitive Reservoir Determination. The Supervisor shall notify the operators when he has made a preliminary determination that a reservoir is competitive as defined in this Order. An operator may request at any time that the Supervisor make a preliminary determination as to whether a reservoir is competitive. The operators, within thirty (30) days of such preliminary notification or such extension of time as approved by the Supervisor, shall advise of their concurrence with such determination, or submit objections with supporting evidence. The Supervisor will make a final determination and notify the operators.

B. *Development and Production Plans.* When drilling and/or producing operations are conducted in a competitive reservoir, the operators shall submit for approval a plan governing the applicable operations. The plan shall be submitted within ninety (90) days after a determination by the Supervisor that a reservoir is competitive or within such extended period of time as approved by the Supervisor. The plan shall provide for the development and/or production of the reservoir, and may provide for the submittal of supplemental plans for approval by the Supervisor.

(1) *Development Plan.* When a competitive reservoir is still being developed or future development is contemplated, a development plan may be required in addition to a production plan. This plan shall include the information required in 30 CFR 250.34. If agreement to a joint development plan cannot be reached by the operators, each shall submit a separate plan and any differences may be resolved in accordance with paragraph 17 of this Order.

(2) *Production Plan.* A joint production plan is required for each competitive reservoir. This plan shall include (a) the proposed MER for the reservoir; (b) the proposed MPR for each completion in the reservoir; (c) the percentage allocation of reservoir MER for each lease involved; and (d) plans for secondary recovery or pressure maintenance operations. If agreement to a joint production plan cannot be reached by the operators, each shall submit a separate plan, and any differences may be resolved in accordance with paragraph 17 of this Order.

C. *Unitization.* The Conservation Manager shall determine when conservation will be best served by unitization of a competitive reservoir, or any reservoir reasonably delineated and determined to be productive, in lieu of a development and/or production plan or when the operators and lessees involved have been unable to voluntarily effect unitization. In such cases, the Conservation Manager may require that development and/or production operations be conducted under an approved unitization plan. Within six (6) months after notification by the Conservation Manager that such a unit plan is required, or within such extended period of time as approved by the Conservation Manager, the lessees and operators shall submit a proposed unit plan for designation of the unit area and approval of the form of agreement pursuant to 30 CFR 250.51.

17. Conferences, Decisions and Appeals. Conferences with interested parties may be held to discuss matters relating to applications and statements of position filed by the parties relating to operations conducted pursuant to this Order. The Supervisor or Conservation Manager may call a conference with one or more, or all, interested parties on his own initiative or at the request of any interested party. All interested parties shall be served with copies of the Supervisor's or Conservation Manager's decisions. Any interested party may appeal decisions of the Supervisor or Conservation Manager pursuant to 30 CFR 250.81. Decisions of the Supervisor or Conservation Manager shall remain in effect and shall not be suspended by reason of any appeal, except as provided in that regulation.

F.J. Schambeck

F. J. Schambeck
Oil and Gas Supervisor
Pacific Area

Approved:

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

APPENDIX A

Subparagraph 12.B "Numbering Well Completions. Well completions made after the date of this Order shall be designated using numerical and alphabetical nomenclature. Once designated as a reservoir or commingled reservoirs completion, the well completion number shall not change. . ."

The intent of this Subparagraph is not necessarily to change the existing well completion names but to change the method of naming well completions after the effective date of this Order in order to insure that a completion in a given reservoir(s) and a specific well bore will be assigned a unique name and will retain the name permanently. For further clarification, the following guidelines and examples are offered:

1. Each well bore will have a distinct, permanent number.

2. Each reservoir or commingled reservoirs completion in a well bore will have a unique permanent designation which includes the well bore number in its nomenclature.

3. For the purpose of this Subparagraph, a "completion" is defined as all perforations in a given reservoir(s) in a specific well bore and is not necessarily associated with a tubing string or strings.

4. If more than one completion is made in a well bore, an alphabetical suffix must be used in the nomenclature to differentiate between completions.

5. An alphabetical prefix may be utilized to designate the platform from which the well will be produced.

Example No. 1: The first well drilled from the A Platform is a single completion.

Well No. A-1

(Should an operator wish to use an alphabetical suffix with a single completion, he may do so.)

Example No. 2: A well drilled by a mobile rig need not carry an alphabetical prefix.

Well No. 1

(If the well is later connected to and produced from a production platform, the well shall be redesignated to reflect an alphabetical prefix.)

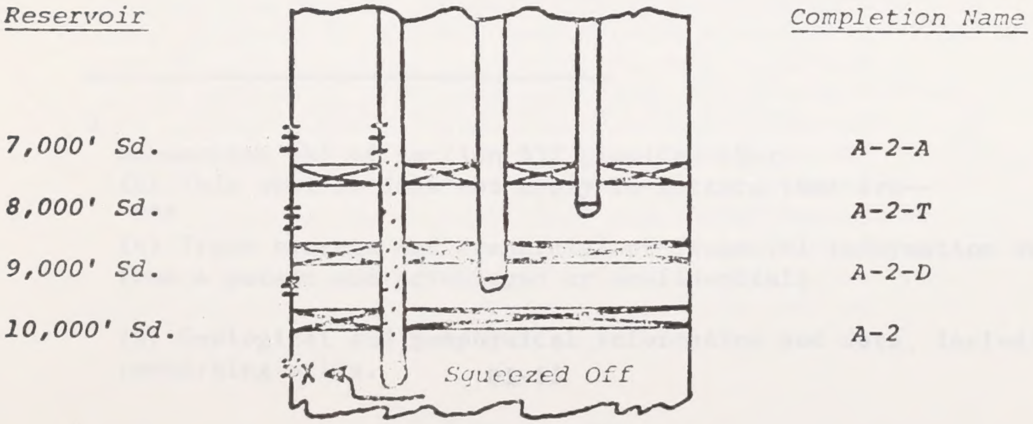
Example No. 3: *The second well drilled from the A Platform is a triple completion.*

First Completion	*Second Completion*	*Third Completion*
A-2	*A-2-D*	*A-2-T*

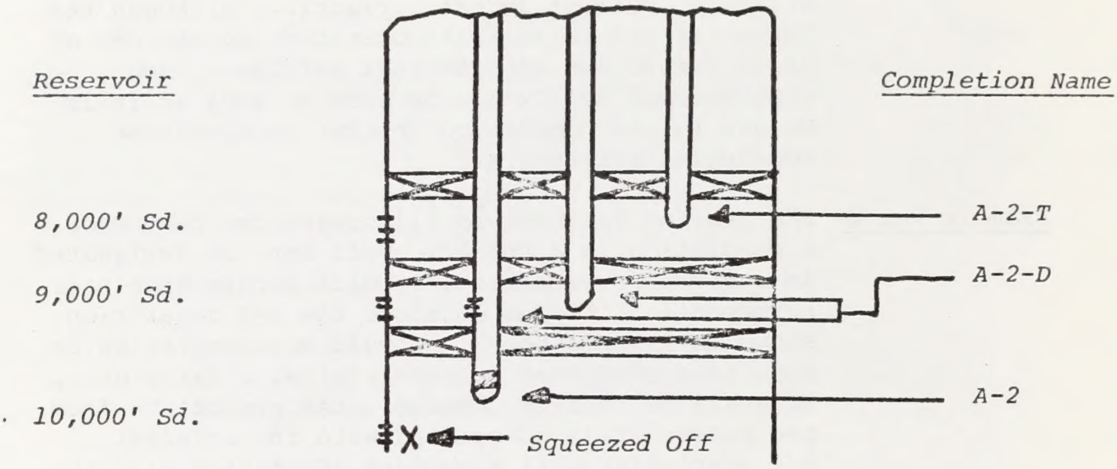
(In the above example, the letters "D" and "T" were used in naming the second and third completions utilizing current industry practice, although the intent is not to restrict operators to the use of these particular alphabetical suffixes. Any alphabetical suffix may be used as long as it is unique to the completion in that reservoir or commingled reservoirs.

Example No. 4: *The drawing is shown to illustrate the fact once a completion in a specific well bore is designated in a given reservoir(s), it will retain that name permanently. Let us consider the A-2 completion shown in Example No. 3. Should a recompletion be made in a different reservoir(s) at a later date, it shall be renamed; however, the production from the reservoir(s) associated with the original A-2 completion will always be identified with the A-2 completion. Once the A-2 completion in the 10,000' sand is squeezed and plugged off and the recompletion made to the 7,000' sand, the completion in the 7,000' sand would be designated A-2-A (or some other alphabetical suffix other than "D" or "T" presently associated with other completions in the 9,000' and 8,000' sands).*

The Sundry notice (Form 9-331) submitted to obtain approval for the workover shall be the vehicle for naming the new completion.



Example No. 5: *If the A-2 completion in Example No. 4 had been recompleted from the 10,000' sand to the 9,000' sand (where the A-2-D is currently completed), the completion would still be named A-2-D as both tubing strings would be considered one completion for purposes of this Order.*



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
PACIFIC AREA

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC AREA

OCS ORDER NO. 12

Effective December 1, 1974

PUBLIC INSPECTION OF RECORDS

This Order is established pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.97 and 43 CFR 2.2 Section 250.97 of 30 CFR provides as follows:

> Public Inspection of Records. Geological and geophysical interpretations, maps, and data required to be submitted under this part shall not be available for public inspection without the consent of the lessee so long as the lease remains in effect or until such time as the Supervisor determines that release of such information is required and necessary for the proper development of the field or area.

Section 2.2 of 43 CFR provides in part as follows:

> Determinations as to Availability of Records. (a) Section 552 of Title 5, U. S. Code, as amended by Public Law 90-23 (the act codifying the "Public Information Act") requires that identifiable agency records be made available for inspection. Subsection (b)[1] of section 552 exempts several categories of records from the general requirements but does not require the withholding from inspection of all records which may fall within the categories exempted. Accordingly, no request made of a field office to inspect a record shall be denied unless the head of the office or such higher field

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[1] Subsection (b) of section 552 provides that:
(b) This section does not apply to matters that are--
***
(4) Trade secrets and commercial or financial information obtained from a person and privileged or confidential;

(9) Geological and geophysical information and data, including maps, concerning wells.

authority as the head of the bureau may designate shall determine (1) that the record falls within one or more of the categories exempted and (2) either that disclosure is prohibited by statute or Executive Order or that sound grounds exist which require the invocation of the exemption. A request to inspect a record located in the headquarters office of a bureau shall not be denied except on the basis of a similar determination made by the head of the bureau or his designee, and a request made to inspect a record located in a major organizational unit of the Office of the Secretary shall not be denied except on the basis of a similar determination by the head of that unit. Officers and employees of the Department shall be guided by the "Attorney General's Memorandum on the Public Information Section of the Administrative Procedure Act" of June 1967.

(b) An applicant may appeal from a determination that a record is not available for inspection to the Solicitor of the Department of the Interior, who may exercise all of the authority of the Secretary of the Interior in this regard. The Deputy Solicitor may decide such appeals and may exercise all of the authority of the Secretary in this regard.

The operator shall comply with the requirements of this Order. All departures from the requirements specified in this Order shall be subject to approval pursuant to 30 CFR 250.12(b).

1. Availability of Records Filed on or After the Effective Date of This Order. It has been determined that certain records pertaining to leases and wells in the Outer Continental Shelf and submitted under 30 CFR 250 shall be made available for public inspection, as specified below, in the Area office, Los Angeles, California.

   A. Form 9-152 - Monthly Report of Operations. All information contained in this form shall be available except the information required in the Remarks column.

   B. Form 9-330 - Well Completion or Recompletion Report and Log.

      (1) Prior to commencement of production, all information contained on this form shall be available except Item 1a, Type of Well; Item 4, Location of Well, At top prod. interval reported below; Item 22, If Multiple Compl., How Many; Item 24, Producing Interval; Item 26, Type Electric and Other Logs Run; Item 28, Casing Record; Item 29, Liner Record; Item 30, Tubing Record; Item 31, Perforation Record; Item 32, Acid, Shot, Fracture, Cement Squeeze, etc.; Item 33, Production; Item 37, Summary of Porous Zones; and Item 38, Geologic Markers.

      (2) After commencement of production, all information shall be available except Item 37, Summary of Porous Zones, and Item 38, Geologic Markers.

(3) If production has not commenced after an elapsed time of five years from the date of filing, Form 9-330 as required in 30 CFR 250.38(b), excluding the total of such time that operations and production are suspended by direction of the Secretary of the Interior or his duly authorized representative, and further excluding the total of such time that operations and production are stopped or prohibited by Court order, all information contained on this form shall be available except Item 37, Summary of Porous Zones; and Item 38, Geologic Markers. Within 90 days prior to the end of the 5-year period, exclusive of exceptions noted above, the lessee or operator shall file a Form 9-330 containing all information requested on the form, except Item 37, Summary of Porous Zones, and Item 38, Geologic Markers, to be made available for public inspection. Objections to the release of such information may be submitted with the completed Form 9-330.

C. Form 9-331 - Sundry Notices and Report on Wells. (1) When used as a "Notice of Intention to" conduct operations, all information contained on this form shall be available except Item 4, Location of Well, At top prod. interval; and Item 17, Describe Proposed or Completed Operations.

(2) When used as a "Subsequent Report of" operations, and after commencement of production, all information contained on this form shall be available except information under Item 17 as to subsurface locations and measured and true vertical depths for all markers and zones not placed on production.

D. Form 9-331C - Application for Permit to Drill, Deepen or Plug Back. All information contained on this form and location plat attached thereto, shall be available except Item 4, Location of Well, at proposed prod. zone; and Item 23, Proposed Casing and Cementing Program.

E. Form 9-1869 - Quarterly Oil Well Test Report. All information contained on this form shall be available.

F. Form 9-1870 - Semi-Annual Gas Well Test Report. All information contained on this form shall be available.

G. Multi-Point Back Pressure Test Report. All information contained on the form used to report the results of required multi-point back pressure test of gas wells shall be available.

H. Sales of Lease Production. Information contained on monthly Geological Survey computer printout showing sales volumes value, and royalty of production of oil, condensate, gas and liquid products, by lease, shall be made available.

2. Filing of Reports. All reports on Form 9-152, 9-330, 9-331, 9-331C, 9-1869, 9-1870, and the forms used to report the results of multi-point back pressure tests, shall be filed in accordance with the following: All reports submitted on these forms after the effective date of this Order shall include a copy with the words "Public Information" shown on the lower right-hand corner. All items on the form not marked "Public Information" shall be completed in full; and such forms, and all attachments thereto, shall not be available for public inspection. The copy marked "Public Information" shall be completed in full, except that the items described in 1.A., B., C., and D. above, and the attachments relating to such items, may be excluded. The words "Public Information" shall be shown on the lower right-hand corner of this set. This copy of the form shall be made available for public inspection.

3. Availability of Records Filed Prior to December 1, 1974. Information filed prior to December 1, 1974, on Forms 9-152, 9-330, 9-331, and 9-331C is not in a form which can be readily made available for public inspection. Requests for information on these forms shall be submitted to the Supervisor in writing and shall be made available in accordance with 43 CFR Part 2.

4. Availability of Inspection Records. All accident investigation reports, pollution incident reports, facilities inspection data, and records of enforcement actions are also available for public inspection.

F. J. Schambeck

F. J. Schambeck
Oil and Gas Supervisor
Pacific Area

Approved: November 21, 1974

Russell G. Wayland

Russell G. Wayland
Chief, Conservation Division

APPENDIX 6

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC REGION

JUN 11 1973

United States Department of the Interior
Geological Survey

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES ON THE OUTER CONTINENTAL SHELF

Enclosed is a copy of the Final Report of a Geological Survey Work Group on Outer Continental Shelf Safety and Pollution Control. The Work Group reviewed the various recommendations of three studies on OCS safety and pollution control, and prepared recommendations for implementation. The three studies are:

1. "Applicability of NASA Contract Quality Management and Failure Mode Effect Analysis Procedures to the USGS Outer Continental Shelf Oil and Gas Lease Management Program," November 1971, by a team of NASA specialists.
2. "Outer Continental Shelf Lease Management Study," May 1972, by a team of Geological Survey systems analysts.
3. "Outer Continental Shelf Resource Development Safety: A Review of Technology and Regulation for the Systematic Minimization of Environmental Intrusion from Petroleum Products," December 1972, by a panel of the Marine Board, National Academy of Engineering.

This is to notify you of the Geological Survey's intention to implement all of the recommendations of the Work Group's report. Some have already been implemented. Others will be the subject of new and revised OCS Orders which, according to our practice, will be discussed with Offshore Operators Committee and Western Oil and Gas Association and published in the Federal Register for public comment before being issued.

We look forward to your continued cooperation in taking all possible measures to ensure the safety of OCS oil and gas operations and protect the environment.

V. E. McKelvey

V. E. McKelvey
Director

Copy to: Offshore Operators Committee
Western Oil and Gas Association

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
PACIFIC AREA

74-2 August 26, 1974

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC AREA

Hydrogen Sulfide in Drilling Operations

When drilling operations are undertaken to penetrate reservoirs known or expected to contain hydrogen sulfide (H_2S), or, if unknown, upon encountering H_2S, the following preventive measures shall be taken to control the effects of the toxicity, flammability, and corrosive characteristics of H_2S. Alternative equipment or procedures that achieve the same or greater levels of safety may be approved by the District Engineer.

1. Personnel Safety and Protection. All personnel shall undergo an eardrum examination before assignment to H_2S prone areas. Personnel with perforated eardrums shall be prohibited from working in an H_2S environment.

    a. Training Program.

    (1) All personnel, whether regularly assigned, contracted, or employed on an unscheduled basis, shall be informed as to the severity of H_2S and sulfur dioxide (SO_2). They shall also be instructed in the proper use of personnel safety equipment and informed of H_2S detectors and alarms, ventilation equipment, prevailing winds, briefing areas, warning systems, and evacuation procedures.

    (2) Information relating to these safety measures shall be prominently posted on the drilling facility and on vessels in the immediate vicinity which are serving the drilling facility.

    (3) To promote efficient safety procedures, an on-site H_2S safety program, which includes a weekly drill and training session, shall be established. Records of attendance shall be maintained on the drilling facility.

    (4) All personnel in the working crew shall have completed a basic first-aid course. During subsequent on-site training sessions and drills, emphasis should be placed upon rescue and first aid for H_2S victims. Each drilling facility shall have the following equipment, and each crew member should be thoroughly familiar with the location and use of these items:

    (a) A Coast Guard-approved first-aid kit, sized for the normal working number of personnel.

(b) Resuscitators, complete with face masks, oxygen bottles, and spare oxygen bottles.

(c) A Stokes litter or equivalent.

(5) One person, who regularly performs duties on the drilling facility, shall be responsible for the overall operation of the on-site safety and training program.

b. Visible Warning System.

(1) Wind-direction equipment shall be installed at prominent locations to indicate to all personnel, on or in the immediate vicinity of the facility, the wind direction at all times for determining safe upwind areas in the event that H_2S or SO_2 is present in the atmosphere.

(2) Operational danger signs shall be displayed from each side of the drilling ship or platform, and a number of rectangular red flags shall be hoisted in a manner visible to watercraft and aircraft. Each sign shall have a minimum width of eight feet and a minimum height of four feet, and shall be painted a high-visibility yellow color with black lettering of a minimum of 12 inches in height, indicating:

"DANGER - HYDROGEN SULFIDE - H_2S"

Each flag shall be of a minimum width of three feet and a minimum height of two feet. All signs and flags shall be illuminated under conditions of poor visibility and at night when in use. These signs shall indicate the following operational conditions and requirements:

(a) SIGNS DISPLAYED: MODERATE DANGER - when the threshold limit value of H_2S (10 parts per million) is reached. If the concentration of H_2S reaches 20 parts per million, protective equipment shall be worn by all personnel, and all nonworking personnel shall proceed to the safe briefing areas.

(b) SIGNS DISPLAYED AND RED FLAG HOISTED: EXTREME DANGER - when H_2S is determined to have reached the injurious level (20 parts per million). Immediately evacuate all nonessential personnel, or all personnel, as appropriate. Radio communications shall be used to alert all known air- and watercraft in the immediate vicinity of this condition.

c. Contingency Plan. A contingency plan shall be developed prior to the commencement of drilling operations which shall include the following:

(1) General information and physiological response to H_2S and SO_2 exposure.

(2) Safety procedures, equipment, and training.

(3) Procedures for operating conditions:

  (a) Moderate danger to life.

  (b) Extreme danger to life.

(4) Responsibilities and duties of personnel for each operating condition.

(5) Designation of briefing areas as locations for assembly of personnel during an extreme danger condition. At least two briefing areas should be established on each drilling facility. Of these two areas, the one upwind at any given time is the safe briefing area.

(6) Evacuation plan.

(7) Agencies to be notified in case of an emergency.

(8) A list of medical personnel and facilities, including addresses and telephone numbers.

d. H_2S Detection and Monitoring Equipment.

(1) Each drilling facility shall have an H_2S detection and monitoring system which activates audible and visible alarms before the concentration of H_2S exceeds its threshold limit value of 10 parts per million in air. This equipment shall be capable of sensing a minimum of 5 parts per million H_2S in air, with sensing points located at the bell nipple, shale shaker, mud pits, driller's stand, living quarters, and other areas where H_2S might accumulate in hazardous quantities.

(2) H_2S detector ampules shall be available for use by all working personnel. After H_2S has been initially detected by any device, periodic inspections of all areas of poor ventilation shall be made with a portable H_2S detector instrument.

e. Personnel Protective Equipment.

(1) All personnel on a drilling facility or aboard marine vessels serving the facility shall be equipped with proper personnel protective breathing apparatus. The breathing apparatus used in an H_2S environment shall conform to all applicable Occupational Safety and Health Administration and American National Standards Institute standards and regulations. Optional equipment, such as nose cups and spectable kits, shall be available for use as needed.

(2) The storage location of protective breathing apparatus shall be such that they are quickly and easily available to all personnel. Storage locations shall include the following:

   (a) Rig floor.

   (b) Any working area above the rig floor.

   (c) Mud logging facility.

   (d) Shale-shaker area.

   (e) Mud pit area.

   (f) Mud storage area.

   (g) Pump rooms (mud and cement).

   (h) Crew quarters.

   (i) Each briefing area.

   (j) Heliport.

(3) A system of breathing-air manifolds, hoses, and masks shall be provided on the rig floor and in the briefing areas. A cascade air bottle system shall be provided to refill individual protective breathing apparatus bottles. The cascade air bottle system may be recharged by a high-pressure compressor suitable for providing breathing-quality air, provided the compressor suction is located in an uncontaminated atmosphere. All breathing-air bottles should be labeled as containing breathing-quality air fit for human usage.

(4) Workboats attendant to rig operations shall be equipped with protective breathing apparatus for all workboat crew members. Pressure demand or demand-type masks, connected to a breathing-air manifold, and extra protective breathing apparatus, shall be provided for evacuees. Whenever possible, boats should be stationed upwind.

(5) Helicopters attendant to rig operations shall be equipped with a protective breathing apparatus for the pilot.

(6) The following additional personnel safety equipment shall be available for use as needed:

   (a) Portable H_2S detectors.

   (b) Retrieval ropes with safety harnesses to retrieve incapacitated personnel from contaminated areas.

(c) Chalk boards and note pads located on the rig floor, in the shale-shaker area, and in the cement pump rooms for communication purposes.

(d) Bull horns and flashing lights.

(e) Resuscitators.

f. Ventilation Equipment. All ventilation devices shall be explosion-proof and situated in areas where H_2S or SO_2 may accumulate. Movable ventilation devices shall be provided in work areas and be multidirectional and capable of dispersing H_2S or SO_2 vapors away from working personnel.

g. Notification of Regulatory Agencies. The following agencies shall be immediately notified under the alert conditions indicated:

(1) Moderate Danger:

(a) U. S. Geological Survey.

(b) U. S. Coast Guard.

(2) Extreme Danger:

(a) U. S. Geological Survey.

(b) U. S. Coast Guard.

(c) Department of Defense.

(d) Appropriate state agencies.

2. Metallurgical Equipment Considerations. Equipment used when drilling zones bearing H_2S shall be constructed of materials which, according to design principles, will be able to resist and/or prevent the phenomena known variously as sulfide stress cracking, hydrogen embrittlement, or stress corrosion cracking. Such equipment includes drill pipe, casing, casing heads, blowout-preventer stack assemblies, kill lines, choke manifolds, and other related equipment. A knowledge of the various interactions between stress, environment, and the metallurgy employed is required for successful operation in H_2S environments. The following general practices are required for acceptable performance:

a. Drill String. Drill strings shall be designed consistent with the anticipated depth, conditions of the hole, and reservoir environment to be encountered. Care shall be taken to minimize exposure to the stresses and yield strengths of the drill string as much as is practical and consistent with the anticipated hole conditions to be encountered.

b. Casing. Casing, couplings, flanges, and related equipment shall be designed for H_2S service. Casing flange bolting shall meet the standards as set forth in the latest edition of National Association of Corrosion Engineers publication 1F-166. Field welding on casing (except conductor and surface strings) is prohibited unless approved by the District Engineer.

c. Wellhead, Blowout Preventers, and Pressure Control Equipment. The blowout-preventer stack assembly shall meet the manufacturer's specifications for H_2S service. Surface equipment such as choke manifold, kill lines, fill-up lines, flowlines, and other related pressure equipment which may contain well fluids shall be designed for H_2S service. Bolting and weldments shall conform to the recommendations as set forth in the latest edition of National Association of Corrosion Engineers publication 1F-166. Elastomers (rubbers), packing, and similar inner parts exposed to H_2S shall be resistant at the maximum anticipated temperature of exposure.

3. Mud Program.

a. Either water- or oil-base muds are suitable for use in drilling formations containing H_2S. If oil-base muds are used, cuttings shall be cleaned of oil prior to disposal into the Pacific Ocean.

b. A pH of 9.5 or above shall be maintained in a water-base mud system to control corrosion and prevent sulfide stress cracking.

c. Consideration shall also be given to the use of H_2S scavengers in both water- and oil-base mud systems.

d. Sufficient quantities of additives shall be maintained on location for addition to the mud system as needed to neutralize H_2S picked up by the system when drilling in formations containing H_2S.

e. The application of corrosion inhibitors to the drill pipe to afford a protective coating or their addition to the mud system may be used as an additional safeguard to the normal protection of the metal by pH control and the scavengers mentioned above.

f. Drilling mud containing H_2S gas shall be degassed at the optimum location for the particular rig configuration employed. The gases so removed shall be piped into a closed flare system and burned at a suitable remote stack.

4. General Operations. All personnel in the working area shall utilize H_2S protective equipment when required, as specified in paragraph 1b. The normal fixed-point monitor system outlined in paragraph 1d may be supplemented with portable H_2S detectors as conditions warrant.

a. Drill String Trips or Fishing Operations. Every effort shall be made to pull a dry drill string. If it should be necessary to pull the drill string wet after penetration of H_2S-bearing zones, increased monitoring of the working area shall be provided and protective breathing apparatus shall be worn under conditions as outlined in paragraph 1b.

b. Circulating Bottoms-up from a Drilling Break, Cementing Operations, Logging Operations, or Well Circulation While Not Drilling. After penetration of an H_2S-bearing zone, protective breathing apparatus must be worn by those personnel in the working area 15 minutes in advance of circulating bottoms-up or when H_2S is indicated by the monitoring system in quantities sufficient to require breathing apparatus under paragraph 1b, should this condition occur earlier.

c. Coring Operations in H_2S-bearing Zones. Personnel protective equipment must be worn 10-20 stands in advance of retrieving the core barrel. Cores to be transported must be sealed and marked for the presence of H_2S.

d. Abandonment or Temporary Abandonment Operations. Internal well-abandonment equipment shall be designed for H2S service.

e. Logging Operations after Penetration of Known or Suspected H_2S-bearing Zones. Equipment used in logging operations shall be treated with H_2S corrosion inhibitors prior to going in the hole.

f. Stripping Operations. Displaced mud returns shall be monitored and protective equipment worn if H_2S is detected at levels outlined for protective equipment under paragraph 1b.

g. Gas-cut Mud or Well Kick from H_2S-bearing Zones. Protective equipment shall be worn when an H_2S concentration of 20 parts per million is detected. Should a decision be made to circulate out a kick, protective equipment shall be worn during the entire operation. Procedures during this period shall be governed by the "Moderate Danger" provision of paragraph 1b.

h. Drill String Precautions. Precautions shall be taken to minimize drill string stresses caused by conditions such as excessive dogleg severity, improper stiffness ratios, improper torque, whip, abrasive wear on tool joints, and joint imbalance. American Petroleum Institute Bulletin RP 7G shall be used as a guideline for drill string precautions. Sulfur-bearing tool-joint compounds shall not be used.

Proper handling techniques shall be employed to prevent notching, stress concentrations, and possible drill pipe failures.

i. Flare System. The flare system shall be designed to safely vent and burn any H_2S gas. Flare lines shall be located as far from the drilling facility as feasible in a manner to compensate for wind changes. The flare system shall be equipped with continuous pilot and an automatic igniter. Backup ignition for each flare shall be provided.

5. Kick Detection and Well Control.

   a. In addition to paragraph 3C, OCS Order No. 2, Pacific Area, all efforts shall be made to prevent a well kick as a result of gas-cut mud, drilling breaks, lost circulation, or trips for bit. Drilling rate changes shall be evaluated for the possibility of encountering abnormal pressures, and mud weights adjusted in an effort to compensate for any hydrostatic imbalance that might result in a well kick.

   b. In the event of a kick, the disposal of the well influx shall be accomplished by one of two alternatives with regard for personnel safety, possible environmental damage, and possible facility or well equipment damage:

      (1) Alternative A: To contain the kick influx by shutting in the well, calculating the necessary mud weight, and pumping the influx back into the formation by injecting barite or kill mud as appropriate.

      (2) Alternative B: To control the kick by using appropriate well-control techniques to prevent formation fracturing in open hole within the pressure limits of well equipment (drill pipe, casing, wellhead, blowout preventers, and related equipment). The disposal of H_2S and other gases shall be through pressured or atmospheric mud-gas separator equipment, depending on volume and pressure of H_2S gas. The equipment shall be designed to recover drilling mud and to vent to the atmosphere and burn the gases separated. The mud system shall be treated to neutralize H_2S and restore and maintain the proper mud quality.

6. Well Testing in an H_2S Environment.

   a. Procedures.

      (1) Well Testing shall be performed with the minimum number of personnel required in the immediate vicinity of the rig floor and test equipment to safely and adequately perform the test and to adequately maintain related equipment and services.

(2) Prior to initiation of the test, special safety meetings shall be conducted for all personnel who will be on the drilling facility during the test, with particular emphasis on use of personnel safety equipment, first-aid procedures, and the H_2S Contingency Plan.

(3) During the test, the use of H_2S detection equipment shall be intensified. All produced gases shall be vented and burned through a flare system which meets the requirements of paragraph 4i. Produced fluids which are stored shall be vented into the flare system.

(4) "No Smoking" rules shall be rigorously enforced.

b. Equipment.

(1) Drill-stem test tools and wellhead equipment shall be suitable for H_2S service.

(2) Tubing which meets the requirements for H_2S service shall be used for drill stem testing. Drill pipe shall not be used for drill stem tests without the prior approval of the District Engineer. The water cushion shall be thoroughly inhibited in order to prevent H_2S corrosion. The test string shall be flushed with treated fluid for the same purpose after completion of the test.

(3) All surface test units and related equipment shall be designed for H_2S service. Only competent personnel who are trained in and knowledgeable of the severity and possible hazardous effects of H_2S shall be utilized in these tests.

F. J. Schambeck
F. J. Schambeck
Oil and Gas Supervisor
Pacific Area

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
PACIFIC AREA

November 1, 1974

NOTICE TO LESSEES AND OPERATORS OF FEDERAL OIL AND GAS LEASES IN THE OUTER CONTINENTAL SHELF, PACIFIC AREA

Royalty Payment on Oil and Gas Lost

This Notice supersedes the Notice issued June 28, 1974, concerning the payment of royalties on oil and gas lost.

Effective June 1, 1974, royalty will be due on all oil and gas produced from all OCS leases, except gas production as provided in paragraph 3. of this Notice. The production subject to royalty, except as provided in paragraph 3., includes that oil and gas which is lost in spills, blowouts, and fires, gas which is vented or flared, and oil and gas used on such leases, all of which are referred to as lost oil and gas in this Notice.

The amount of oil and gas lost and the royalty value accruing to the United States as a result of these losses shall be reported monthly on Form 9-153. Payment of royalty shall be made on these amounts of oil and gas subject to the determination by the Oil and Gas Supervisor that such royalty value is properly calculated pursuant to 30 CFR 250.20. Additional measurement equipment shall be required where present methods are inadequate to satisfy the purposes of this Notice.

The operator shall comply with the following specific requirements:

1. Volume Determination

A. Oil and Gas Lost After Measurement

When the amount of oil and gas produced has been measured pursuant to 30 CFR 250.60 and 250.61, prior to any loss of such oil and gas, that measurement shall be the basis for the volume determination.

B. Oil and Gas Lost Prior to Measurement

The volume of oil and gas lost prior to the point of measurement shall be determined as follows:

(1) Emergencies. During emergency situations, the volume of oil and gas lost shall be estimated by comparison

with the last measured throughput from the production facilities on the lease or unitized area where the loss occurs considering factors such as the duration of the emergency, individual well tests, daily lease production rates, historical production data, or by such other methods as may be approved by the Supervisor.

(2) Well Purging and Evaluation Tests. The results of previous production tests and the duration of the test period shall form the basis for determining the volume of oil and gas lost during well evaluation tests. The volumes of oil and gas lost as a result of well purgings shall be similarly determined.

2. Value Determination for Royalty Purposes

A. Gas

In the absence of a sales contract or other agreement, gas which is lost shall be valued at no less than the highest price then provided by existing contracts for gas for the same lease or unitized area, field, or general area or at the prevalent area or other rate established by the Federal Power Commission in accordance with 30 CFR 250.64.

B. Oil

In computing the royalty due on oil which is lost, the value of such oil shall be computed in the same manner as the Supervisor calculates the value of other oil sold from the lease or unitized area, field, or general area in accordance with 30 CFR 250.64.

3. Gas Production on Which Royalty Shall Not Accrue

A. Royalty shall accrue on all gas produced under leases which are issued pursuant to section 8 of the OCS Lands Act (43 U.S.C. § 1337) and which provide that "gas used for purposes of production from and operations upon the leased area or unavoidably lost" is not subject to royalty, except as provided below. All lessees are advised, however, that on August 26, 1974, the Chairman, Conservation and Natural Resources Subcommittee of the House Committee on Government Operations requested the Comptroller General to determine the validity of this provision which has been included in section 8 leases. Accordingly, the Department will consider the opinion of the Comptroller General when issued and decide subsequently whether the payment of additional royalty may be required of these lessees. Therefore, all lessees whose leases are subject to paragraph 3A are required to keep records of all gas volumes excluded under paragraph 3A so that the amount of royalty may be determined if the lease provision is ultimately found to be invalid.

(1) Reinjected Gas. Gas which is produced pursuant to a lease or unit agreement, and which is reinjected into a well or formation subject to that lease or unit agreement to aid in the recovery of oil and gas in a manner which renders that gas reasonably subject to later extraction, will not be subject to the payment of royalty until finally produced and not so reinjected. However, the operator shall report monthly to the Supervisor on Form 9-152 the volume of gas so produced and reinjected.

(2) Other Lease Use. Gas produced pursuant to a lease or unit agreement and used for operations or production activities pursuant to that same lease or unit agreement as a fuel or otherwise in the operation of machinery or equipment shall not be subject to royalty, unless it is a use which the Supervisor has prohibited.

(3) Gas Vapor Losses. Gas vapors which are released from storage tanks or other low-pressure production vessels and which are not collected by a vapor recovery unit or similar system when the Supervisor determines that such vapors may not feasibly be collected shall not be subject to royalty.

(4) Other Lost Gas. Gas which is lost in blowouts, fires, or otherwise exclusive of subparagraph 3.A.(3) above shall be considered unavoidably lost and not subject to royalty unless (i) there has been negligence on the part of the lessee or operator, or (ii) the lessee or operator has failed to take all reasonable precautions against such loss, or (iii) there has been a violation of the applicable regulations or OCS Orders. Where gas is intentionally flared or vented, the gas shall not be considered unavoidably lost and royalty shall accrue.

B. Royalty shall accrue on all gas produced under leases which are issued pursuant to section 8 of the OCS Lands Act and which do not provide that "gas used for purposes of production from and operations upon the leased area or unavoidably lost" is not subject to royalty, and under leases maintained pursuant to section 6 of the Act, except as provided below.

(1) Reinjected Gas. Gas which is produced pursuant to a lease or unit agreement, and which is injected into a

well or formation subject to that lease or unit agreement to aid in the recovery of oil and gas in a manner which renders that gas reasonably subject to later extraction, will not be subject to the payment of royalty until finally produced and not so reinjected. However, the operator shall report monthly to the Supervisor on Form 9-152 the volume of gas so produced and reinjected.

(2) *Gas Vapor Losses.* Gas vapors which are released from storage tanks or other low-pressure production vessels and which are not collected by a vapor recovery unit or similar system when the Supervisor determines that such vapors may not feasibly be collected, shall not be subject to royalty.

F. J. Schambeck

F. J. Schambeck
Oil and Gas Supervisor
Pacific Area

APPENDIX 7

SAMPLE OUTER CONTINENTAL SHELF LEASE FORM

Form 3300–1
(February 1971)
(formerly 3380–1)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

OIL AND GAS LEASE OF SUBMERGED LANDS UNDER THE OUTER CONTINENTAL SHELF LANDS ACT

Office

Serial Number

Cash Bonus

Rental Rate

Minimum Royalty Rate | Royalty Rate

This lease is made and effective as of (hereinafter called the Effective Date) by and between the United States of America (hereinafter called the Lessor), by the , Bureau of Land Management, its authorized officer, and

(hereinafter called the Lessee). In consideration of the cash payment heretofore made by the Lessee to the Lessor and in consideration of the promises, terms, conditions and covenants contained herein, the parties hereto agree as follows:

Sec. 1. Statutes and Regulations. This lease is made pursuant to the Outer Continental Shelf Lands Act of August 7, 1953 (67 Stat. 462; 43 U.S.C. Secs. 1331, *et seq.*) (hereinafter called the Act). This lease is subject to all the provisions of the Act and to all the terms, conditions and requirements of the valid regulations promulgated by the Secretary of the Interior (hereinafter called the Secretary) thereunder in existence upon the effective date of this lease, all of which are incorporated herein and, by reference, made a part hereof. This lease shall also be subject to regulations hereafter issued by the Secretary pursuant to his authority under section 5(a)(1) of the Act to prescribe and amend at any time such rules and regulations as he may determine to be necessary and proper in order to provide for the prevention of waste and for the conservation of the natural resources of the Outer Continental Shelf, and for the protection of correlative rights therein, which regulations shall be deemed incorporated herein and, by reference, made a part hereof when promulgated.

Sec. 2. Rights of Lessee. The Lessor hereby grants and leases to the Lessee the exclusive right and privilege to drill for, mine, extract, remove and dispose of oil and gas deposits, except helium gas, in or under the following-described area of the Outer Continental Shelf of the United States:

containing approximately acres (hereinafter referred to as the leased area), together with:

(a) the nonexclusive right to conduct within the leased area geological and geophysical explorations in accordance with applicable regulations;

(b) the nonexclusive right to drill water wells within the leased area and to use water produced therefrom for operations pursuant to the Act free of cost, provided that such drilling is conducted in accordance with procedures approved by the Regional Oil and Gas Supervisor of the Geological Survey (hereinafter called the "Supervisor"); and

(c) the right to construct or erect and to maintain within the leased area all artificial islands, platforms, fixed or floating structures, sea walls, docks, dredged channels and spaces, buildings, plants, telegraph or telephone lines and cables, pipelines, reservoirs, tanks, pumping stations, and other works and structures necessary to the full enjoyment of the rights granted by this lease, subject to compliance with applicable laws and regulations.

Sec. 3. Obligations of Lessee. The Lessee agrees:

(a) *Rentals and royalties.* (1) To pay rentals and royalties as follows:

Rentals. With respect to each lease year commencing prior to a discovery of oil or gas on the leased area, to pay the Lessor on or before the first day of each such year, a rental of per acre or fraction thereof.

Minimum royalty. To pay the Lessor at the expiration of each lease year commencing after discovery a minimum royalty of per acre or fraction thereof or, if there is production, the difference between the actual royalty required to be paid with respect to such lease year and the prescribed minimum royalty, if the actual royalty paid is less than the minimum royalty.

Royalty on production. To pay the Lessor a royalty of percent in amount or value of production saved, removed, or sold from the leased area. Gas of all kinds (except helium and gas used for purposes of production from and operations upon the leased area or unavoidably lost) is subject to royalty.

(2) It is expressly agreed that the Secretary may establish minimum values for purposes of computing

royalty on products obtained from this lease, due consideration being given to the highest price paid for a part or for a majority of production of like quality in the same field, or area, to the price received by the Lessee, to posted prices, and to other relevant matters. Each such determination shall be made only after due notice to the Lessee and a reasonable opportunity has been afforded the Lessee to be heard.

(3) When paid in value, royalties on production shall be due and payable monthly on the last day of the month next following the month in which the production is obtained. When paid in production, such royalties shall be delivered at pipeline connections or in tanks provided by the Lessee. Such deliveries shall be made at reasonable times and intervals and, at the Lessor's option, shall be effected either (i) on or immediately adjacent to the leased area, without cost to the Lessor, or (ii) at a more convenient point closer to shore or on shore, in which event the Lessee shall be entitled to reimbursement for the reasonable cost of transporting the royalty substance to such delivery point. The Lessee shall not be required to provide storage for royalty taken in kind in excess of tankage required when royalty is paid in value. When payments are made in production the Lessee shall not be held liable for the loss or destruction of royalty oil or other liquid products in storage from causes over which the Lessee has no control.

(b) *Bonds.* To maintain at all times the bond required prior to the issuance of this lease and to furnish such additional security as may be required by the Lessor if, after operations or production have begun, the Lessor deems such additional security to be necessary.

(c) *Wells.* (1) To diligently drill and produce such wells as are necessary to protect the Lessor from loss by reason of production on other properties or, in lieu thereof, with the consent of the Supervisor, to pay a sum determined by the Supervisor as adequate to compensate the Lessor for failure to drill and produce any such well. In the event that this lease is not being maintained in force by other production of oil or gas in paying quantities or by other approved drilling or reworking operations, such payments shall be considered as the equivalent of production in paying quantities for all purposes of this lease.

(2) After due notice in writing, to diligently drill and produce such other wells as the Secretary may reasonably require in order that the leased area or any part thereof may be properly and timely developed and produced in accordance with good operating practice.

(3) At the election of the Lessee, to drill and produce other wells in conformity with any system of well spacing or production allotments affecting the area, field, or pool in which the leased area or any part thereof is situated, which is authorized or sanctioned by applicable law or by the Secretary.

(d) *Payments.* To make all payments to the Lessor by check, bank draft or money order payable as indicated herein unless otherwise provided by regulations or by direction of the Secretary. Rental, royalties, and other payments shall be made payable to the United States Geological Survey and tendered to the Supervisor, *except* that filing charges, bonuses, and first year's rental shall be made payable to the Bureau of Land Management and remitted to the Manager of the appropriate field office of that Bureau.

(e) *Inspection.* To keep open at all reasonable times for the inspection of any duly authorized representative of the Lessor, the leased area and all wells, improvements, machinery and fixtures thereon and all books, accounts, and records relative to operations and surveys or investigations on or with regard to the leased area or under the lease.

(f) *Conduct of operations.* To conduct all operations under this lease in accordance with applicable law and regulations.

(g) *Indemnification.* To indemnify and save the Lessor harmless against and from any and all claims of any nature whatever, including without limitation claims for loss or damage to property or injury to persons, caused by, or resulting from, any operation on the leased area conducted by or on behalf of the Lessee; provided that the Lessee shall not be held responsible to the Lessor under this subsection for any loss, damage, or injury caused by, or resulting from: (1) any negligent action of the Lessor other than the exercise or performance of (or the failure to exercise or perform) a discretionary function or duty on the part of a Federal agency or an employee of such an agency, whether or not the discretion involved is abused; or (2) the Lessee's compliance with an order or directive of the Lessor against which an appeal by the Lessee under 30 CFR 250.81 is filed before the cause of action for such a claim arises and is pursued diligently thereafter.

(h) *Equal Opportunity Clause.* The Lessee agrees that, during the performance of this lease:

(1) The Lessee will not discriminate against any employee or applicant for employment because of race, color, religion, sex or national origin. The Lessee will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex or national origin. Such action shall include, but not be limited to the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Lessee agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Lessor setting forth the provisions of this Equal Opportunity clause.

(2) The Lessee will, in all solicitations or advertisements for employees placed by or on behalf of the Lessee, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex or national origin.

(3) The Lessee will send to each labor union or representative of workers with which Lessee has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the Lessor, advising the labor union or workers' representative of the Lessee's commitments under this Equal Opportunity clause, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(4) The Lessee will comply with all provisions of Executive Order No. 11246 of September 24, 1965, as amended, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(5) The Lessee will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, as amended, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the Secretary of the Interior and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(6) In the event of the Lessee's noncompliance with the Equal Opportunity clause of this lease or with any of said rules, regulations, or orders, this lease may be canceled, terminated or suspended in whole or in part and the Lessee may be declared ineligible for further Federal government contracts or leases in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, as amended, and such other sanctions may be imposed and remedies invoked as provided in Executive Order No. 11246 of September 24, 1965, as amended, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

(7) The Lessee will include the provisions of paragraphs (1) through (7) of this subsection 3(h) in

every contract, subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to section 204 of Executive Order No. 11246 of September 24, 1965, as amended, so that such provisions will be binding upon each contractor, subcontractor or vendor. The Lessee will take such action with respect to any contract, subcontract or purchase order as the Secretary may direct as a means of enforcing such provisions including sanctions for noncompliance; *provided, however,* that in the event the Lessee becomes involved in, or is threatened with, litigation with a contractor, subcontractor or vendor as a result of such direction by the Secretary, the Lessee may request the Lessor to enter into such litigation to protect the interests of the Lessor.

(i) *Certification of nonsegregated facilities.* By entering into this lease, the Lessee certifies that Lessee does not and will not maintain or provide for Lessee's employees any segregated facilities at any of Lessee's establishments, and that Lessee does not and will not permit Lessee's employees to perform their services at any location, under Lessee's control, where segregated facilities are maintained. The Lessee agrees that a breach of this certification is a violation of the Equal Opportunity clause in this lease. As used in this certification, the term "segregated facilities" means, but is not limited to, any waiting rooms, work areas, rest rooms and wash rooms, restaurants and other eating areas, time clocks, locker rooms and other storage or dressing areas, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for employees which are segregated by explicit directive or are in fact segregated on the basis of race, color, religion, or national origin, because of habit, local custom, or otherwise. Lessee further agrees that (except where Lessee has obtained identical certifications from proposed contractors and subcontractors for specific time periods) Lessee will obtain identical certifications from proposed contractors and subcontractors prior to the award of contracts or subcontracts exceeding $10,000 which are not exempt from the provisions of the Equal Opportunity clause; that Lessee will retain such certifications in Lessee's files; and that Lessee will forward the following notice to such proposed contractors and subcontractors (except where the proposed contractor or subcontractor has submitted identical certifications for specific time periods):

Notice to prospective contractors and subcontractors of requirement for certification of nonsegregated facilities. A Certification of Nonsegregated Facilities, as required by the May 9, 1967, order (32 F.R. 7439, May 19, 1967) on Elimination of Segregated Facilities, by the Secretary of Labor, must be submitted prior to the award of a contract or subcontract exceeding $10,000 which is not exempt from the provisions of the Equal Opportunity clause. The certification may be submitted either for each contract and subcontract or for all contracts and subcontracts during a period (i.e., quarterly, semiannually, or annually).

(j) *Assignment of lease.* To file for approval with the appropriate office of the Bureau of Land Management any instrument of transfer of this lease, or any interest therein, required to be filed under applicable regulations, within the time and in the manner prescribed by the applicable regulations.

Sec. 4. Term. This lease shall continue for a period of 5 years from the effective date of this lease and so long thereafter as oil or gas may be produced from the leased area in paying quantities, or drilling or well reworking operations, as approved by the Secretary, are conducted thereon.

Sec. 5. Cooperative or Unit Plan. Lessee agrees that, within 30 days after demand by Lessor, Lessee will subscribe to and operate under such cooperative or unit plan for the development and operation of the area, field, or pool, or part thereof, embracing lands subject to this lease as the Secretary may determine to be practicable and necessary or advisable in the interest of conservation. Where any provision of a cooperative or unit plan of development which has been approved by the Secretary, and which by its terms affects the leased area or any part thereof, is inconsistent with a provision of this lease, the provision of such cooperative or unit plan shall govern.

Sec. 6. Reservations to Lessor. All rights in the leased area not expressly granted to the Lessee by the Act, the regulations, or this lease are hereby reserved to the Lessor. Without limiting the generality of the foregoing, such reserved rights include:

(a) *Geological and geophysical exploration rights-of-way.* The right to authorize the conduct of geological and geophysical exploration in the leased area which does not interfere with or endanger actual operations under this lease, and the right to grant such easements or rights-of-way upon, through, or in the leased area as may be necessary or appropriate to the working of other lands or to the treatment and shipment of products thereof by or under authority of the United States, its Lessees or Permittees.

(b) *Leases of sulfur and other minerals.* The right to grant leases of any mineral other than oil and gas within the leased area or any part thereof. No lease of other mineral shall authorize or permit the Lessee thereunder unreasonably to interfere with or endanger operations under this lease.

(c) *Purchase of production.* In time of war, or when the President of the United States shall so prescribe, the right of first refusal to purchase at the market price all or any portion of the oil or gas produced from the leased area, as provided in Section 12(b) of the Act.

(d) *Taking of royalties.* The right to determine whether royalty will be taken in the amount or the value of production.

(e) *Helium.* Pursuant to Section 12(f) of the Act, the ownership of and the right to extract helium from all gas produced under this lease.

(f) *Suspension of operations during war or national emergency.* Upon recommendation of the Secretary of Defense, during a state of war or national emergency declared by the Congress or President of the United States after August 7, 1953, the authority of the Secretary to suspend any or all operations under this lease, as provided in Section 12(c) of the Act. *Provided,* That just compensation shall be paid by the Lessor to the Lessee.

(g) *Restriction of exploration and operations.* The right, as provided in Section 12(d) of the Act, to restrict from exploration and operations the leased area or any part thereof which may be designated by and through the Secretary of Defense, with the approval of the President, as, or as part of, an area of the Outer Continental Shelf needed for national defense; and so long as such designation remains in effect no exploration or operations may be conducted on the surface of the leased area or the part thereof included within the designation except with the concurrence of the Secretary of Defense; and if operations or production under this lease within any such restricted area shall be suspended, any payments of rentals and royalty prescribed by this lease likewise shall be suspended during such period of suspension of operations and production, and the term of this lease shall be extended by adding thereto any such suspension period, and the Lessor shall be liable to the Lessee for such compensation as is required to be paid under the Constitution of the United States.

Sec. 7. Directional Drilling. A directional well drilled under the leased area from a surface location on nearby land not covered by this lease shall be deemed to have the same effect for all purposes of this lease as a well drilled from a surface location on the leased area. In such circumstances, drilling shall be considered to have

been commenced on the leased area when drilling is commenced on the nearby land for the purpose of directionally drilling under the leased area, and production of oil or **gas** from the leased area **through any** directional well surfaced on nearby land or drilling or reworking of any such directional well shall be considered production or drilling or reworking operations (as the case may be) on the leased area for all purposes of this lease. Nothing contained in this paragraph is intended or shall be construed as granting to the Lessee any leasehold interests, licenses, easements, or other rights in or with respect to any such nearby land in addition to any such leasehold interests, licenses, easements, or other rights which the Lessee may have lawfully acquired under the Act or from the Lessor or others.

Sec. 8. Surrender of Lease. The Lessee may surrender this entire lease or any officially designated subdivision of the leased area by filing with the appropriate office of the Bureau of Land Management a written relinquishment, in *triplicate*, which shall be effective as of the date of filing. No surrender of this lease or of any portion of the leased area shall relieve the Lessee or his surety of the obligation to make payment of all accrued rentals and royalties or to abandon all wells on the area to be surrendered in a manner satisfactory to the Supervisor.

Sec. 9. Removal of property on termination of lease. Upon the termination of this lease in whole or in part, or the surrender of the lease in whole or in part, as herein provided, the Lessee shall within a period of 1 year thereafter remove from the premises no longer subject to the lease all structures, machinery, equipment, tools, and materials in accordance with applicable regulations and orders of the Supervisor; *provided, however,* that the Lessee may continue to maintain any such property on the leased area for whatever longer period it may be needed, as determined by the Supervisor, for producing wells or for drilling or producing on other leases.

Sec. 10. Remedies in case of default. (a) Whenever the Lessee fails to comply with any of the provisions of the Act, or of this lease, or of the regulations issued under the Act and in force and effect on the effective date of this lease, the lease shall be subject to cancellation in accordance with the provisions of Section 5(b) of the Act; *provided, however,* **that the 30-day notice provision applicable to non-producing leases under Section 5(b)(1) of the Act shall also apply as a prerequisite to the institution of any legal action by the Lessor to cancel this lease while it is in a producing status.** Nothing in this subsection shall be construed to apply to, or require any notice with respect to, any legal action instituted by the Lessor other than an action to cancel the lease pursuant to Section 5(b) of the Act.

(b) Whenever the Lessee fails to comply with any of the provisions of the Act, or of this lease, or of any regulations promulgated by the Secretary under the Act, the Lessor may exercise any legal or equitable remedy or remedies which the Lessor may have, including appropriate action under the penalty provisions of Section 5(a)(2) of the Act; *however,* the remedy of cancellation of the lease may be exercised only under the provisions of Section 5(b) and Section 8(i) of the Act.

(c) A waiver of any particular violation of the provisions of the Act, or of this lease, or of any regulations promulgated by the Secretary under the Act, shall not prevent the cancellation of this lease or the exercise of any other remedy or remedies under paragraphs (a) and (b) of this section by reason of any other such violation or for the same violation occurring at any other time.

Sec. 11. Heirs and successors in interest. Each obligation hereunder shall extend to and be binding upon, and every benefit hereof shall inure to, the heirs, executors, administrators, successors, or assigns, of the respective parties hereto.

Sec. 12. Unlawful interest. No member of, or Delegate to, Congress, or Resident Commissioner, after his election or appointment, or either before or after he has qualified, and during his continuance in office, and no officer, agent, or employee of the Department of the Interior, except as provided in 43 CFR 7.4(a)(1), shall be admitted to any share or part in this lease or derive any benefit that may arise therefrom; and the provisions of Section 3741 of the Revised Statutes (41 U.S.C. Sec. 22), as amended, and Sections 431, 432, and 433 of Title 18 of the United States Code, relating to contracts made or entered into, or accepted by or on behalf of the United States, form a part of this lease so far as the same may be applicable.

THE UNITED STATES OF AMERICA

______________________________ By______________________________

(Signature of Lessee) (Authorized Officer)

______________________________ ______________________________

(Signature of Lessee) (Title)

______________________________ ______________________________

(Signature of Lessee) (Date)

______________________________ ______________________________

(Signature of Lessee)

If this lease is executed by a corporation, it must bear the corporate seal

APPENDIX 8

Description of Operations

1. Geophysical Exploration

a. Industry

In order to locate potential hydrocarbon deposits, the oil industry must analyze the substructure of the area. The prime objective of the analysis is to locate geologic structures that are favorable for the accumulation of petroleum. A knowledge of the subsurface geologic environment is also necessary to detect near surface conditions, such as recent faulting or high pressure zones, which are potential hazards to exploration and production operations. Once hazardous conditions are identified, drilling programs are modified to assure safety of operations.

When lease sales are to be conducted, industry normally conducts regional geophysical surveys of an area of interest, prior to a call for nomination of lease sale tracts by the Department of the Interior. These surveys provide a network of modern state-of-the-art common depth point (CDP) seismic lines on approximately a 4-mile-by-4 mile grid spacing to provide data for reconnaissance mapping. In some cases an even closer 2-mile-by-2 mile line spacing may be used. If an oil company plans to submit lease tract nominations to the Department, then more detailed seismic data are collected and interpreted in order that potentially productive tracts may be identified.

In seismic exploration, a ship travels along a predetermined path, towing signal-generating and recording equipment. The signal generated by the energy source is a series of small amplitude sonic pulses that travel at thousands of feet per second through the water and sediments below, where they are reflected and refracted by the underlying strata. An array of sensitive hydrophones towed by the vessel detect incoming (returning) sonic waves which are recorded on magnetic tape. After extensive processing, these recordings are displayed in the form of vertical cross-sections. These seismic profiles are interpreted to identify those areas in which the sediments are arched, faulted, and where they thicken or thin, and where reef structures occur. By assembling cross-sections along traverses made in various directions, a three-dimensional picture can be constructed, indicating location, size, and form of geologic structures favorable for oil and gas accumulation. This information is normally displayed in the form of a series of subsurface structure contour maps.

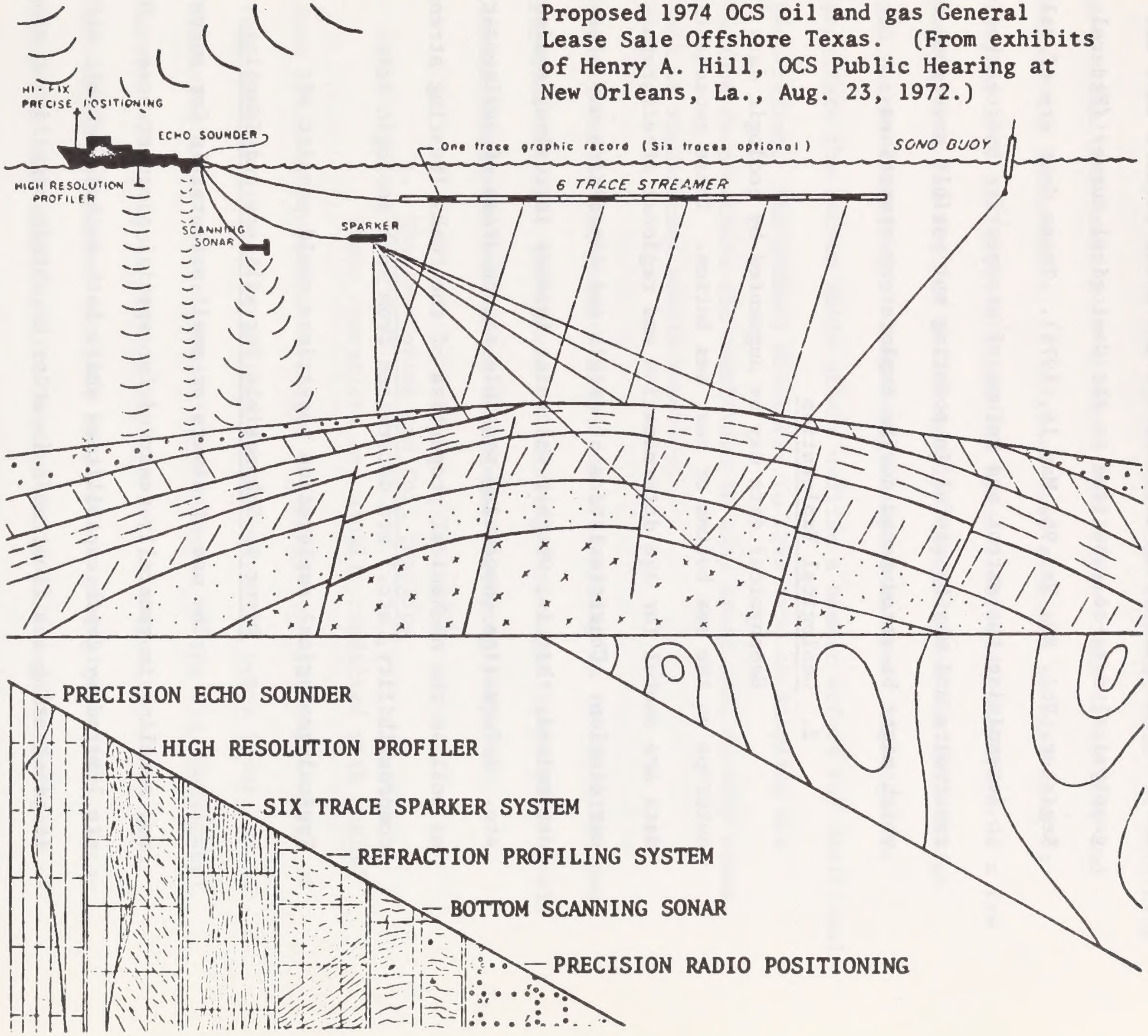
In early years of offshore exploration the energy source for the sonic wave was explosive charges detonated in the water layer. Because of the hazards associated with the use of explosives to the vessel crew, and natural marine life, new equipment and methods have evolved and now account for more than 95 percent of marine geophysical activity. In particular, the use of a vibrator system, sparkers, air guns, and gas guns now provide excellent seismic data, with no harmful effect on the marine environment.

In addition to the deep penetration CDP seismic reflection data, some companies purchase and interprete shallow penetration high resolution acoustic data to locate potential sea bottom or near bottom geologic hazards. Such hazards as shallow geologic structures, unstable bottom sediments, faults, and seeps may be predicted from these data and thus minimize any hazards to drilling operations and possible consequent dangers to the environment from pollution. These are used as guides to regulate platform and well locations as well as drilling procedures. A typical high resolution data acquisition system is illustrated in figure 1.

b. U.S. Geological Survey

Regulations in existence on September 1974, do not require companies to submit their geophysical data to the USGS, except for a plat showing the location of the lines run and the total miles run during any particular survey. An exception to this is that shallow, site-specific high resolution data is required by the Pacific Area Oil and Gas Supervisor before a permit for operations involving penetration of the ocean floor can be approved.

Figure -1 Geophysical and Seismic Data Collecting
Source: BLM, Final EIS, FES-74-14, Proposed 1974 OCS oil and gas General Lease Sale Offshore Texas. (From exhibits of Henry A. Hill, OCS Public Hearing at New Orleans, La., Aug. 23, 1972.)



Proposed Geological and Geophysical Exploration Regulations for the OCS are presently being considered which would require that all geophysical data be submitted to the Geological Survey (Federal Register, Vol. 39, No. 96, May 16, 1974). These data are of value in determining the extent and volume of prospective hydrocarbon reservoirs and may be useful in pointing out posible hazardous zones which might be encountered during exploratory operations.

2. Geological Exploration

Geophysical data may be augmented by geologic data from outcrops on the sea bottom or near sea bottom. These geoscientific data are useful for age determination and regional stratigraphic correlation. Characteristics of origin and deposition may also be determined, that is, whether volcanic, igneous intrusive, sedimentary, etc. Information concerning possible source areas of sedimentary beds as well as the mechanical properties of the rocks (bearing strength, compressibility, etc.) are determined from such geologic data.

Typical geological exploration operations could consist of:

a. Diver or Submersible Surveillance and Sampling

The use of divers or small submersible for surveillance and sampling is generally reserved for special circumstances. Divers are limited by depth capabilities while both methods exhibit difficulty in penetrating sea floor muds in order to obtain significant samples. However, the use of side scan sonar from submersible vehicles has been extremely successful in mapping sea floor geomorphology.

b. Dart Sampling

This method is the one most commonly used for obtaining geological information in offshore operations since it is fast and relatively inexpensive. A weighted tube attached to wire line is dropped over the side, strikes the ocean floor and recovers from a few inches to a few feet of bottom samples depending on the tool design and bottom conditions. Some designs depend entirely on weight to penetrate the bottom while others utilize a hammer effect for additional penetration. The primary drawbacks to this type of sampling are failure to penetrate the overburden in many areas and, in many cases, lack of significant sample recovery.

Because one of the primary functions of sampling is to correlate geophysical surveys, the amount of sampling that might be proposed would depend largely on the amount of seismic surveying proposed.

c. Shallow Coring and Soil Sampling

These operations are usually conducted with scaled down drilling equipment developed to operate on shipboard. Most of this work is limited to shallow depths below the ocean floor and is conducted under strict permitting procedures by the U.S. Geological Survey. The purpose of this work is not to encounter oil or gas, but simply to recover suitable samples for geological study. Locations for each sampling site are carefully selected on the basis of prior geophysical surveys to insure that the sites are in non-hazardous areas (areas free of seeps, geologic closures, acoustic voids, etc.).

Generally the operations are carried out in much the same manner as conventional drilling, the primary difference being that the only connection between the ocean floor and the drilling vessel is the drilling string. No riser pipe is used and therefore there is no return circulation of drilling fluid to the surface vessel. Drill cuttings and drilling fluid are circulated out the hole and deposited on the ocean floor. Sea water or a non-toxic salt water base mud that is not harmful to marine life is used as the drilling fluid.

Core samples are recovered through the hollow drill pipe using wire-line methods because once drilling is initiated the drill string cannot be recovered without losing the hole. Upon completion of drilling, permit stipulations require that the holes be plugged with cement to insure against the possibility of any seeps developing at a later date.

This type of operation is generally used where the other types of sample recovery, such as dart sampling, give inconclusive results or where information on underlying formations is required. Data on soil-bearing strength are of particular value when structures such as platforms are designed for emplacement on the ocean floor.

Present permit stipulations limit shallow coring for geological purposes to a depth of 500 feet below the ocean floor; however, if a competent formation has not been encountered, coring can be continued to a maximum total depth of 750 feet, except that no more than 50 feet of competent formation, below 500 feet, can be penetrated.

The extent and quantity of shallow coring operations that might be proposed would depend largely on the individual operator's requirements. However, the number of such programs are limited by USGS permit stipulations which require that all interested persons be allowed to participate in such programs and that duplicate locations are prohibited.

3. Exploratory Drilling

Drilling is the only presently known technique available to determine the presence of a hydrocarbon reservoir and to delineate its boundaries and characteristics. Drilling can be divided into two broad categories, i.e., (i) Exploratory drilling to discover a reservoir, to delineate its boundaries, and to determine its characteristics; (ii) Development drilling to realize the potential of the reservoir most economically.

Offshore exploratory drilling today is generally conducted from a floating vessel or from a mobile "jack-up" platform. The latter type platforms are of many configurations, but can most generally be compared to a barge on which all drilling equipment, as well as auxillary facilities such as living quarters, helicopter deck, etc., are mounted. The platform may or may not be self-propelled. The platform is equipped with three or more legs suspended in "jacks" which serve to raise or lower the legs in a vertical direction. When moving the platform, the legs are elevated. On arrival at the drilling location, the legs are lowered to the bottom and the platform is elevated on the legs to a position above the water surface. The platform is then essentially a fixed platform and drilling is conducted in the same manner as from a fixed platform (see section 3.h.). There is a further discussion of jack-up platforms in Appendix 9.

For these reasons, only floating vessel drilling will be discussed in this section. General features of a floating vessel drilling system are illustrated in figure 2.

Subsea completions discussed later in this section would also probably utilize floating vessel drilling.

a. Features of Floating Vessel Drilling

Whether drilling is conducted on land, a platform, or from a floating vessel, most of the requirements are similar. Drilling from a floating vessel, however, requires certain modifications in procedures and, in some cases, equipment modifications. Five areas of major differences in procedures can be identified for floating vessel drilling, they are:

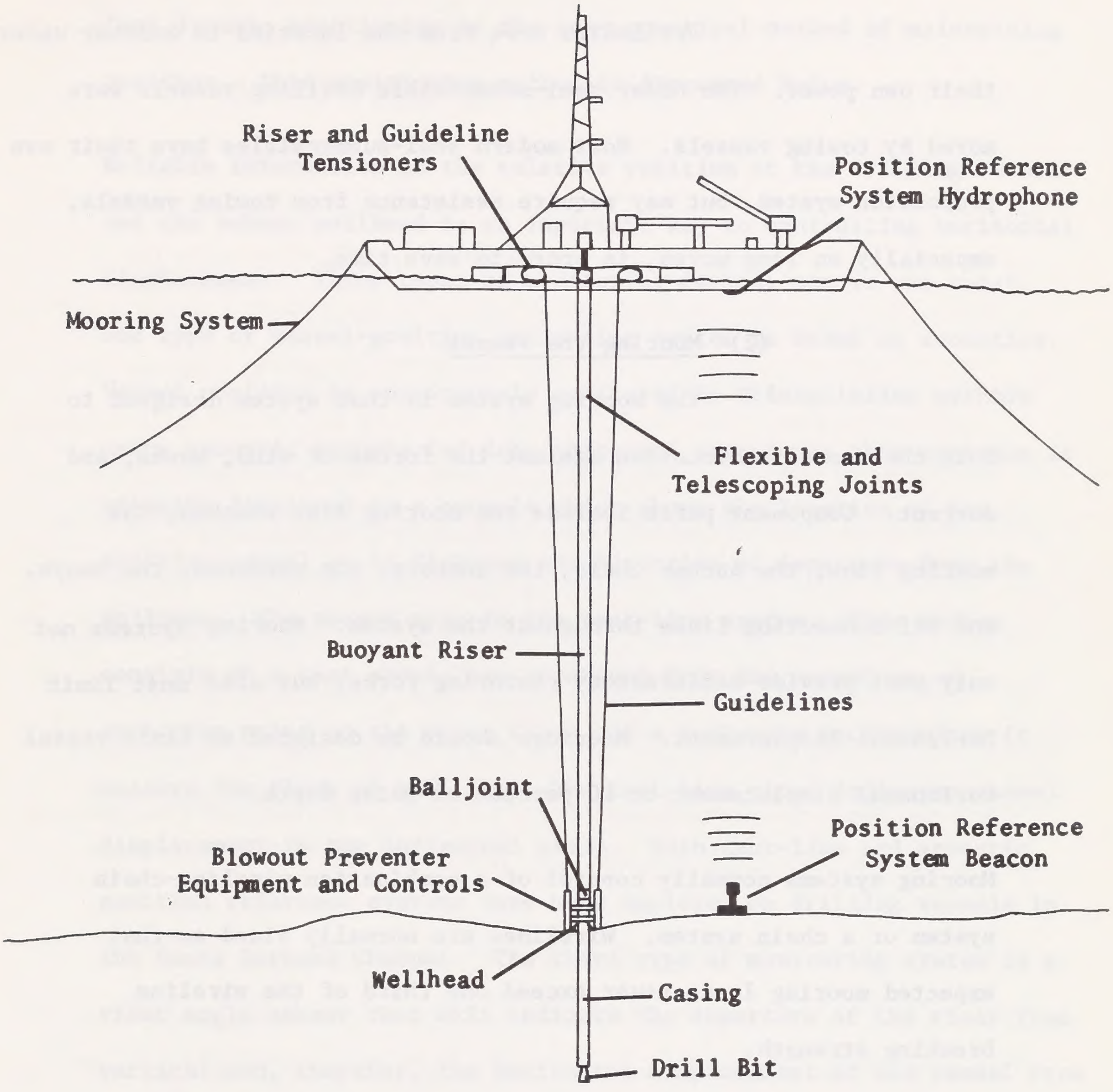

Riser and Guideline Tensioners
Position Reference System Hydrophone
Mooring System
Flexible and Telescoping Joints
Buoyant Riser
Guidelines
Balljoint
Position Reference System Beacon
Blowout Preventer Equipment and Controls
Wellhead
Casing
Drill Bit

Figure 2. Components of a Deepwater Exploratory Drilling System

(1) Movement of the Vessels from One Location to Another

Drillships move from one location to another under their own power. The older semi-submersible drilling vessels were moved by towing vessels. Most modern semi-submersibles have their own propulsion system, but may require assistance from towing vessels, especially on long moves, in order to save time.

(2) Mooring the Vessel

The mooring system is that system designed to hold the vessel on location against the forces of wind, waves, and current. Component parts include the mooring line winches, the mooring line, the anchor chain, the anchors, the pendants, the buoys, and all connecting links throughout the system. Mooring systems not only must provide satisfactory restoring force, but also must limit horizontal displacement. Moorings should be designed to limit vessel horizontal displacement to 10 percent of water depth.

Mooring systems normally consist of a combination wireline-chain system or a chain system. Wirelines are normally sized so that expected mooring loads never exceed one third of the wireline breaking strength.

In practice, chain-only mooring systems are used in water depths to about 1,000 feet. Combination cable and chain systems can be used to depths of about 2,000 feet. At depths over about 1,000 feet it is generally considered prudent to employ dynamic positioning in conjunction with a mooring system and at depths greater than 2,000 feet dynamic positioning is the only practical method of maintaining position. This positioning method is discussed below.

Reliable information on the relative position of the drilling vessel and the subsea wellhead is an important key to controlling horizontal displacement. Three types of monitoring devices are in use today. One type of vessel-position indicating system is based on acoustics. Vessel position is continuously monitored by triangulation methods using acoustic signals fed into shipboard computers; this position is visually displayed on a console which shows the location of the drilling vessel as to distance and direction of departure from the wellhead. The second type is the taut-line system. This system consists of a taut steel line stretched from the vessel to an anchoring point on the ocean floor and a dual-axis inclinometer to measure the slope of the line. The taut-line slope indicates vessel displacement in the horizontal plane. Both taut-line and acoustic position reference systems have been employed on drilling vessels in the Santa Barbara Channel. The third type of monitoring system is a riser angle sensor that will indicate the departure of the riser from vertical and, therefor, the horizontal displacement of the vessel from the wellhead location. The output from these monitoring systems is fed to a shipboard computer system and the output from the computer controls the tension in mooring system lines to maintain the vessel in position.

The more modern drilling vessels, both drillships and semi-submersibles, have in addition to the main fore and aft propulsion system, a "thruster" propulsion system. This system makes possible lateral, or sideways, movement of the vessel through screws or jets perpendicular to the fore and aft axis of the vessel. The combination of fore and aft, and lateral propulsion systems permits accurate positioning of the vessel in relation to a fixed point.

In practice, on location, the output of the thrusters and main propulsion system is computer controlled. The input to the computer is from the position monitoring system described above, the output from the computer controls the thrusters and main propulsion system to maintain the vessel on position. In water depths from about 1,000 to 2,000 feet this dynamic positioning system is generally used in conjunction with a conventional mooring system. In depths over 2,000 feet, the system can be used alone to maintain position.

Core holes were successfully drilled, and re-entered, by the Glomar Challenger in water depths up to 20,000 feet. Conventional cased wells have been successfully drilled and re-entered using this method, without the aid of divers, in waters up to 2,150 feet deep off Gabon in Africa.

Generally there are at least two positioning systems for redundance and of course the vessel can also be manually controlled to maintain position in case of failure of computer systems.

(3) Vessel Motion Compensation

Because of the flexibility of the drill string and due to the ball joints incorporated in the riser system (described in section 3 b. (3).), horizontal motion of the drilling vessel in relation to the ocean floor wellhead can be accepted up to at least 10 percent of the water depth.

One of the requirements for successful rotary drilling is to maintain a constant weight on the bit. Drilling from a floating vessel which moves up and down in relation to the ocean floor requires special methods to maintain a constant weight on the bit. The riser system is equipped with telescoping joints to permit vertical motion of the vessel. The bottom hole assembly of the drill string is also equipped with telescoping joints, called bumper subs, for the same purpose. Hydraulic or pneumatic vertical motion compensators have also been developed and are in use on many vessels. In one system the compensator is placed in the drill string below the traveling block. In another, the compensator is a part of the crown block, which is normally fixed in place at the top of the derrick, but in this system the crown block moves to compensate for vertical motion of the drilling vessel. Both systems maintain a constant drill string weight on the bit. Thus, as the vessel moves up and down, the drill string automatically maintains its position relative to the bottom. These compensators have been designed with as much as 400,000-lb. capacity and a 14-foot stroke. Figure 3 shows a typical hydraulic vertical motion compensator.

(4) Remote Location of Well Control Equipment

In floating vessel drilling, the wellhead and the blowout preventer (BOP) stack are located on the ocean floor. Therefore, all of the functions normally carried out just below the drilling floor on land and platform drilled wells must be conducted by remote control.

Valves are remotely operated (hydraulically, pneumatically, or electrically) through lines run in conjunction with the guidance and riser systems (section 3.b.(3)). Most of these valves are of the fail-close type which will automatically shut in the well should loss of control power occur. Kill and choke lines are also run with these systems to permit circulation in case the blowout preventers are closed.

Positioning systems to permit the installation of equipment in its proper alignment are generally mechanical and are discussed under guidance systems in section 3.b.(3)&(4) . Visual observation of these functions is made possible by underwater television systems which are in use on many vessels. A back-up system can be provided by divers or submersibles, but the trend is away from these methods as deeper water drilling is attempted.

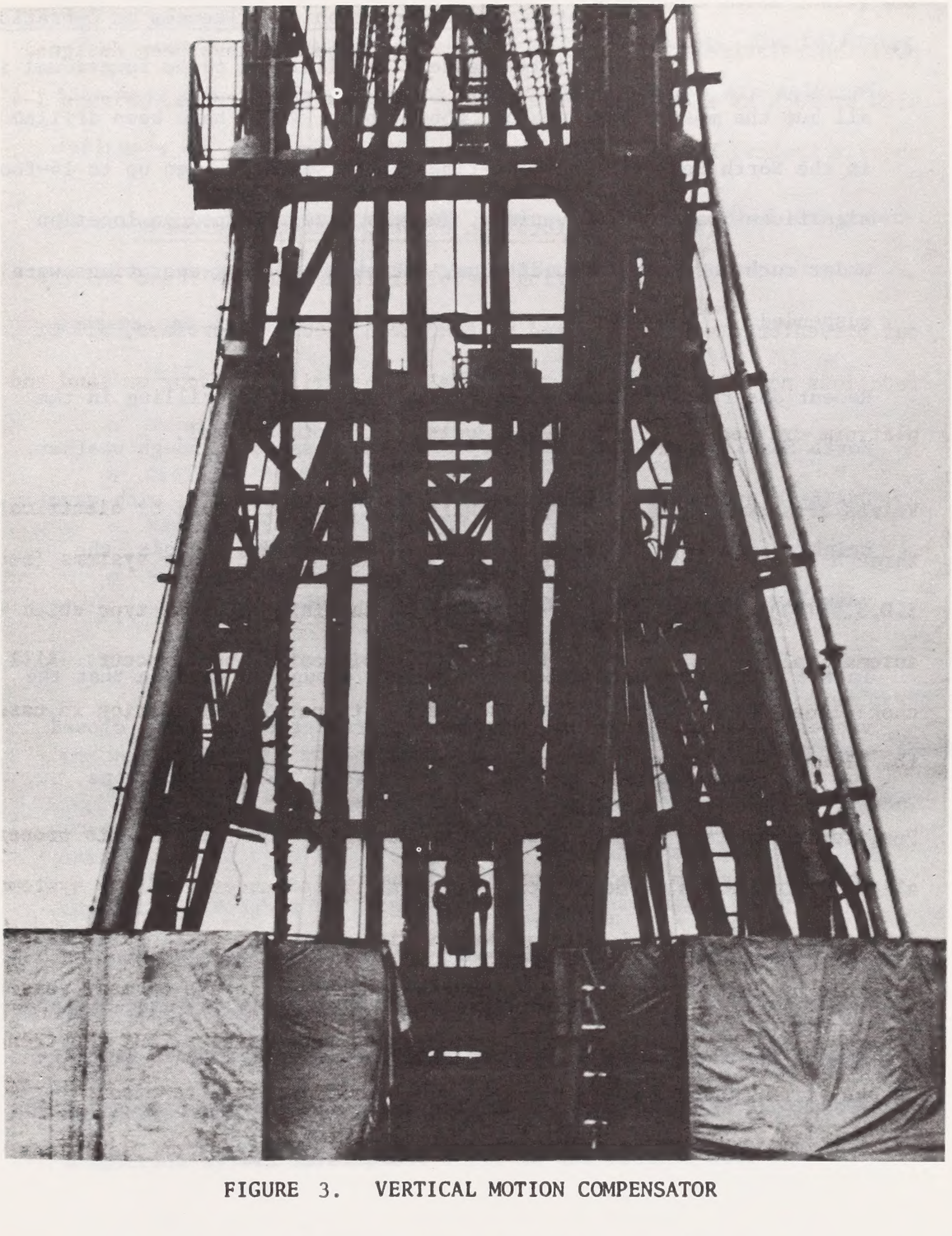


FIGURE 3. VERTICAL MOTION COMPENSATOR

Source: VETCO OFFSHORE. INC

(5) Weather and Oceanographic Influences on Operations

Drilling vessels are designed to be functional in all but the most severe weather conditions. Wells have been drilled in the North Sea, with no down-time due to weather, when up to 14-foot significant waves were running. Vessels have remained on location under much more severe conditions, although drilling operations were suspended.

Recent observations from a modern semi-submersible drilling in the North Sea indicate the stability of these vessels in rough weather. During a storm period reaching 9 on the Beaufort Scale, with wave heights from 16 to 45 feet and 8 to 12 second wave periods, the vessel's heave ranged only from 1.5 to 7 feet.

In the event that conditions were severe enough to require that the vessel leave the location, the blowout preventers would be closed and the riser system retrieved by the vessel. When conditions permitted, the vessel would resume its location as before, re-run the riser system, and resume operations.

b. Drilling Equipment

In implementing a drilling program, a lease operator should focus on two objectives: (i) to conduct efficient drilling operations using advanced technology; and (ii) to conduct operations in a safe manner, with emphasis on maintaining well control and protecting the environment against accidental spills. The following discusses how floating drilling equipment components are selected, designed, and utilized to meet these objectives.

Floating drilling operations can be more easily described and understood by first separating the components into five categories, or systems, as follows:

- Drill Vessel
- Mooring System
- Drilling System
- Marine Well Control System
- Special Operating Techniques

(1) Drill Vessel

The term "drill vessel" is used here to refer to the vessel or hull from which drilling operations are conducted. There are two types of vessels utilized for the preponderance of deepwater drilling. One type is a conventional drillship where drilling is conducted through a vertical water-tight shaft (moon pool) built through the hull of the ship. The other type is a semi-submersible drilling platform with a structural configuration in which the main buoyancy members are located below wave action. Each of the types would be considered acceptable for drilling exploratory and submerged production system development wells in the Pacific OCS.

The semi-submersibles are large, advanced-design rigs that have better motion characteristics in rough seas than do ship types. The units can work in water depths to 1,000 feet and beyond. Vessels are being developed which have the capability to drill in over 3,000 feet of water.

(2) Mooring System

The mooring system was discussed in section 3.a.(2). on Features of Floating Vessel Drilling.

(3) Drilling System

Components included in the drilling system are generally the same components found on most rotary rigs and are associated with all drilling operations whether on land or offshore. Those include the equipment for (i) hoisting the pipe, (ii) rotating the drill string, (iii) circulating the drilling fluid and (iv) the associated auxillary facilities. Since these are common drilling components and not unique to floating vessel drilling, no description will be included here.

(a) Drilling Riser and Well Control Conduits

One part of the floating vessel drilling system that is unique to floating vessel drilling is the riser system. The riser itself is a large diameter pipe connected to the top of the blowout preventer stack by a hydraulic connector. All drilling operations after the conductor pipe is set are carried on through the riser and the primary functions of the risers are to permit circulation of drilling mud and cuttings from the bottom of the hole to the drilling vessel, and to serve as a drill pipe guide.

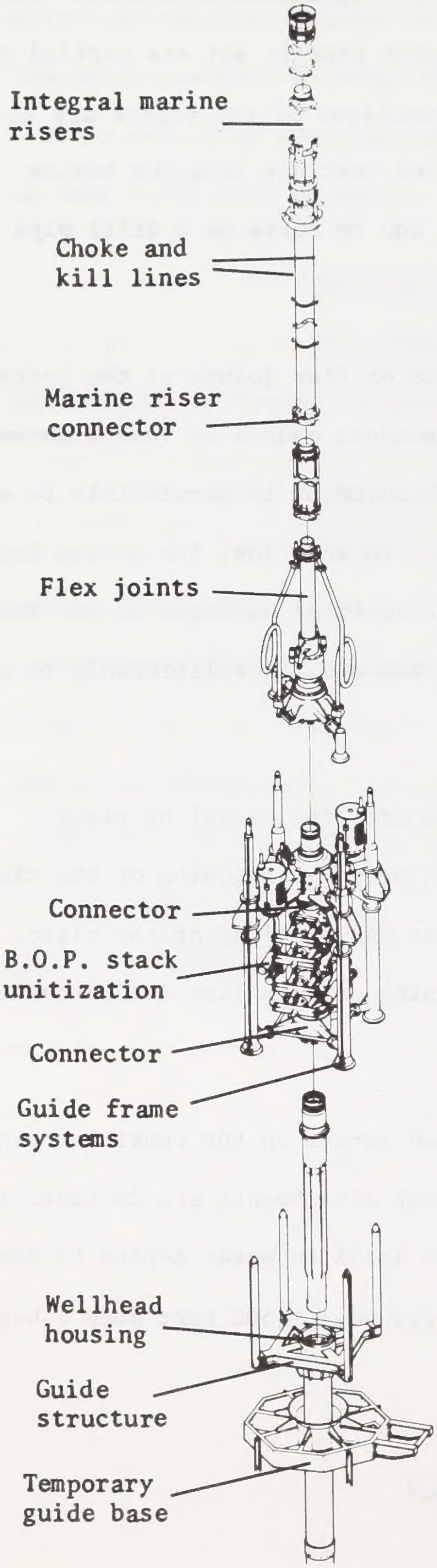
The riser system includes ball joints or flex joints at the bottom and near the top to reduce bending moments caused by vessel movement in the horizontal plane. Horizontal movement is permissible to at least 10 percent of the water depth. In addition, the system includes telescoping or slip joints to permit vertical movement of the vessel. Figure 4. shows a typical riser system and its relationship to other components of the drilling system.

The riser system is connected to the drilling vessel by riser tensioner lines designed to maintain proper tensioning of the riser. This is necessary to avoid overstress and buckling of the riser. In late model vessels proper tensioning of each line is controlled through a computer system.

In deeper water, in order to diminish stress on the tensioner lines, buoyant riser joints or external float attachments are included in the riser string. It is possible to drill in water depths to about 1,500 feet without help, but in waters over 1,500 feet deep a buoyant riser system is a necessity.

Fig. 4.

MARINE WELL CONTROL
SYSTEM



MARINE RISER SYSTEM

The Marine Riser System functions to carry drilling fluid returns back to the drilling vessel. The Riser System incorporates a flexible joint at its lower extremity to isolate the blowout preventer and the wellhead from bending loads should the vessel move off location. A telescopic joint, located near the top, accommodates the vertical reciprocating motion of the vessel.

BLOWOUT PREVENTER STACK

Comprised of large diameter, high pressure valves, the Blowout Preventer provides the ability to securely control variation in well bore pressures during the drilling operation. Duplicate hydraulic control systems assure reliability of preventer operation at all times.

WELLHEAD ASSEMBLY

The wellhead assembly functions as a pressure vessel to which the casing strings are securely sealed as they are installed in the wellbore. The outer profile of the wellhead provides the means of attaching the blowout preventer stack.

GUIDANCE SYSTEM

The permanent guide base run with the conductor casing. The temporary guide base run on drill pipe. The guide bases incorporated in the assembly function as an anchor for guidelines extending from the drill vessel and provide initial support for the installation of the wellhead assembly.

Source: VETCO OFFSHORE , INC.

Riser length has been one of the limiting factors in deepwater drilling, from the standpoint of strain on the tensioning system and on storage and handling facilities on the drilling vessel. However, Shell Oil Company is currently drilling a well in 2,300 feet of water off Morocco and that vessel's riser system is designed for 3,000 feet of water depth.

Kill and choke lines are integral within the riser system to minimize running and pulling time. Connections of these lines to the BOP and manifolding are such that the lines can be operated as either kill or choke lines. Well control conduits are also run simultaneously with the riser system.

(b) Vertical Motion Compensation

The second part of the drilling system unique to floating drilling is the vertical motion compensation system. This was discussed in section 3.a.(3).

(4) Marine Well Control System

The well control system is the composite of those components that provide for utilization and control of, and communication with, the subsea well during drilling operations. Major components of the system are:

- Guidance System
- Wellhead
- Well Casing
- Blowout Preventer Stack and Controls
- Drilling Riser

(a) Guidance System

A guidance system is one of the first ties made between the ocean floor and the drilling vessel. This consists of two or more wirelines attached to a fixed ocean floor structure and tensioned by hydraulic and/or pneumatic units on the vessel. These lines serve as guides for running the drill pipe, blowout preventer (BOP), riser system, and television camera if used.

A typical guide structure is shown in figure 4 . This structure is run and set on the drill string. Structural casing is set through the guide structure by drilling, driving, or jetting to a depth of at least 100 feet. If drilled or jetted in place this casing is cemented in place with a quantity of cement sufficient to fill the annulus to the ocean floor. Conductor casing is then set and cemented in place through the structural casing to a depth of from 300 to 500 feet below the ocean floor. The wellhead casing hanger system is run with this casing string. The blowout preventer assembly and the riser systems are then installed and the actual drilling proceeds. Subsequent casing strings are run through the wellhead casing hanger system and seated as run.

The guidance system described above is typical, but various companies have adopted different methods that vary in details from the one described. Some systems make use of acoustic beacons to re-enter the sea floor assembly.

(b) Wellhead

Subsea wellhead equipment and casing programs are similar in most respects to the land counterparts. The equipment differs principally in that it incorporates provision for remote installation on the ocean floor. The primary function of the wellhead is to hang the casing strings and to serve as the base for the BOP stack. After the well is drilled, tested, and completed the wellhead assembly will serve as the base for the christmas tree assembly and any other subsea production equipment that may be installed.

(c) Well Casing

Formation pressures and fluids are isolated by setting and cementing steel casing strings as drilling progresses. The USGS approves casing programs submitted by lease operators which incorporate appropriate safety factors for maximum potential pressures. Casing setting depths comply with, or exceed, all applicable regulations. Pipe quality, dimensions, weights, grade, yield strenghts, etc. are also regulated by the USGS. Cementing programs and practices are approved and regulated by the USGS. The Operator must comply with all OCS order casing requirements plus any other requirements the Oil and Gas Supervisor deem necessary.

(d) Blowout Preventer Stack

The blowout prevention equipment (BOPE) used in floating drilling operations is essentially the same as that described in Appendix 9 for land drilling. The principal difference, is that all the valves comprising the stack are run at one time as a unit and connected to the conductor casing with a hydraulic connector. The provisions to control the preventers are also more elaborate due to the remote location of the stack. Figure 4 shows the relation of the underwater blowout preventer (BOP) stack to other elements of a floating vessel drilling system.

A more detailed discussion of the blowout prevention equipment and functions is given in section 3.d.(3). Blowout preventers and other well control equipment must meet the Geological Survey requirements. This equipment is tested on a schedule set by prudent practice, but not less often than is specified in Geological Survey regulations (OCS Order No. 2).

(e) Drilling Riser and Well Control Conduits

The riser system was discussed in section 3.b.(3)(a).

c. Safety Features of Marine Well Control System

The marine well control system of wellhead, BOP, controls and riser is the most vital component of the floating drilling system. It is also the most vulnerable. For this reason, the system must be designed as safe as possible compatible with the applicable safety features available to industry at the time and pursuant to Survey regulations.

The following sections enumerate the design criteria established by Geological Survey OCS Orders for the components and outline under each its special safety features:

(1) Maximum Reliability

- o Pressure ratings in excess of those which may be encountered.
- o Fail-safe design of all critical functions.
- o Dual separate fail-safe valving on critical lines and outlets.
- o Two blowout preventer (BOP) side outlets and manifolding such that kill and choke lines can be operated as either kill or choke lines.
- o Adequate ocean floor storage of hydraulic power for cycling all critical functions in case of loss of surface connected power hose.
- o Fast closure of blowout preventers (BOP) provided by ocean floor hydraulic power supply.
- o Redundant control systems and pilot valves which can be retrieved individually and repaired without pulling BOP stack.
- o Established operating practice to alternate use of control systems weekly to insure both are functional.
- o Established practice to suspend operations when either control system is not functional, while conducting repairs.
- o High level preventative maintenance such as sandblasting and magnafluxing riser joints, then repainting. Also, inspection for wear and testing functional capability of each piece prior to installation.
- o Assembling, activating, and pressure testing each function of BOP on board vessel prior to installation.
- o Functional testing of BOP daily and pressure testing weekly, or when changes are made.

(2) Well Closure in the Event of an Emergency

- Optimum ram closure around drill pipe to allow circulation of drilling fluid in the event of a well kick.
- BOP facilities to sustain emergency well control conditions over prolonged periods.
- Provision for hanging drill pipe on rams and moving drilling vessel off location.
- Capability to re-establish vessel on location, monitor and circulate well prior to reconnecting drill pipe.
- Provisions for alternate procedures should any of the foregoing fail.
- Drill with a float valve in the drill string to prevent reverse flow.
- Automatic locks on all ram-type preventers.
- All marine connectors through top of BOP stack designed to handle full-well pressure adequately.
- Annular preventer equipped with automatic closure or acoustically operated closure device in case of loss of control hoses.

(3) Completely Diverless Operation

- Provision for remote operation and remote recovery.
- Appropriate redundancy in all valves and controls.
- Provisions for latching and re-establishing guidelines.

(4) Simplified Installation

- Integration of choke and kill lines into marine riser to simplify simultaneous installation of riser and control lines.
- Run well control systems simultaneously with riser.
- Before landing BOP stack, install upper components (ball joint, telescoping joint and riser tensioning). This allows easy precision control in lowering last few feet with tensioning system.

d. Well Control

In sections 3.b.(4) and 3.c. above, the mechanical well control systems were discussed. However, well control is actually maintained through a variety of inter-related systems. The primary means of well control is the weighted column of drilling fluid (mud) in the hole. The weight of this column serves to control subsurface formation pressures and to prevent formation fluids from entering the well bore. The well casing, is the secondary means of well control since, when casing is run and cemented through a formation, that formation is isolated from the well bore and from other formations. The blowout preventer system is the third means of well control and is designed to be used if the primary system fails.

(1) Drilling Fluid

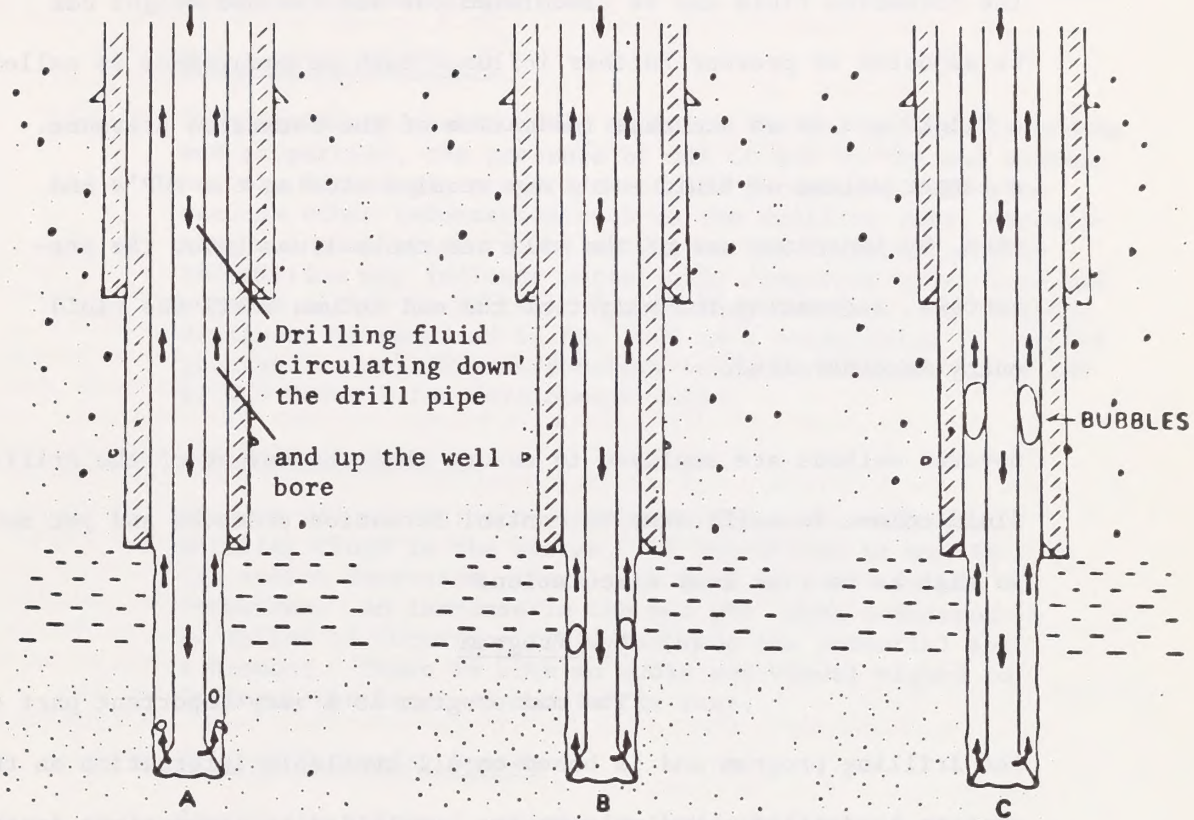
During drilling the well bore is kept filled by circulating the drilling fluid (mud) through the drillstring, out the bit, and up to the surface through the annulus. The weight per volume of the drilling fluid (mud) can be controlled by the addition of weight material (bentonite) through a very wide range to give the desired hydrostatic pressure on bottom. This pressure is designed to be in excess of any natural formation pressure that may be encountered.

The pressure exerted by the mud column is a function of the mud weight and the height of the column. Should the formation pressure be allowed to exceed the pressure exerted by the column of drilling fluid, the column of mud would be forced up and out of the well and an uncontrolled flow of gas, oil, or water could ensue if proper control measures were not taken.

There are two ways in which the formation pressure may exceed the hydrostatic pressure of the mud column. The first, of course, is when the weight per volume of the mud is insufficient. The second is when the height of the column is allowed to decrease to the point where the hydrostatic pressure of the mud column is less than the formation pressure. Some formations contain highly permeable zones which will accept large quantities of the drilling fluid and result in "lost circulation". As the drilling fluid is lost to the formation, the height of the column will fail and a point may be reached where another formation will release formation fluid to the well bore.

When gas, or any formation fluid that is lighter than the drilling fluid, is allowed to enter the well bore, the weight per volume of the drilling fluid is decreased. The effect is cumulative; as formation fluid enters the well bore, the weight of the drilling fluid decreases thus allowing a continually increasing rate of formation fluid entry. Figure 5 illustrates this process.

FIGURE 5. Gas Influx



A "kick" is a gas or liquid influx that reduces the hydrostatic head in the annulus. Here, the kick is a gas bubble (A). As it rises (B and C), it expands.

(Adopted from Panel on Operational Safety in Offshore Resource Development, "Outer Continental Shelf Resource Development Safety", Marine Board of National Academy of Engineering, December, 1972).

If the volume of formation fluid that enters the well bore is not excessive but a surface indication of some influx of formation fluid is observed, such as a slight gain of liguid in the tanks, the formation fluid can be circulated out and the mud weight can be adjusted to prevent further influx. Such an occurrence is called a "kick" and is an accurate indication of the formation pressure. A larger volume of fluid entry may require closing the BOP's and then, by judicious use of the kill and choke lines below the preventers, increasing the weight of the mud column until the fluid entry is controlled.

Several methods are employed to ensure that the weight of the drilling fluid column is sufficient to control formation pressure and yet not so high as to risk lost circulation:

(a) Mud Program

The mud program is a very important part of the drilling program and is based on all available information on the area to be drilled. Mud weights are specifided at the various depths to be drilled and changeover points are indicated where high pressure or loss-of-circulation zones can be expected. Naturally, in development drilling this program can be very detailed and based on known information. In exploratory drilling, the program must be based on general knowledge, inference, and experience. As an exploratory well is drilled, the mud program is adjusted to fit conditions as they are encountered. Mud programs are reviewed and approved by the USGS.

(b) Mud Monitoring and Control

- The Mud Engineer

  The drilling fluid (mud) engineer makes periodic mud property tests and prescribes the treatment required to obtain or maintain the desired properties.

- Mud Logging Equipment

  This equipment continuously monitors the mud system, recording mud properties, the presence of oil or gas in the mud system, and the lithologic properties of the formations. It also records other information such as the drilling rate, circulating mud pump pressure and weight on the drill bit. This information may indicate potentially dangerous situations and permits action to be taken before they develop. Mud logging equipment is required by the USGS as a stipulation to permits granted for drilling exploratory wells in offshore areas and by OCS Order 2 for development wells.

- Pit Volume Indicator

  The pit volume indicator indicates the total volume of drilling fluid in the system. If the volume of mud in the system decreases, there is a loss of fluid to the formation. An increase in the mud pit level indicates an inflow of formation fluid and thus the potential for a blowout. There is both an audio and visual signal to indicate the level of mud in the sump.

- Fill-up Measuring System

  One of the critical periods in the drilling of a well is when the drillstring is removed from the hole. As the pipe is pulled from the hole, its equivalent volume must be replaced by mud to maintain the hydrostatic pressure on the formation. A calibrated fill-up tank is maintained for this purpose. As pipe is pulled, the quantity of mud required to replace its volume is metered. Any difference between pipe volume and replacement mud volume will indicate a potential hazardous situation.

- Mud Degasser

  Gas may enter the mud system as discussed above, or merely from the gas contained in the pores of the formation being crushed by the bit. The mud viscosity may prevent the release of small gas bubbles and thus there is a possibility of a continuing decrease in the mud weight per volume. A mud degasser is included in the mud system to remove any entrained gas from the mud before it returns to the mud pit. This prevents continued lightening of the mud and also prevents any hazardous gas buildup at the mud pit.

- Down-Hole Gas Influx Indicator

  A new method of indicating gas entry into the well-bore during drilling presently is being developed and tested. It essentially involves the use of a tool included in the drillstring that will trap a sample of the drilling fluid from the bottom of the hole. By lifting the drillstring, the chamber in which the sample is confined is enlarged, thereby reducing the pressure on the sample and allowing any entrapped gas to escape and expand. The energy resulting from gas expansion will be reflected on the surface weight indicator as a diminution of the work required to lift the drillstring. The time required for this operation is only about 30 seconds and the advantage is that gas entry can be detected immediately and at the point of entry. The other methods discussed above depend on surface indications that are delayed due to the time required to circulate fluid to the surface. This method is still in the development stage, but it may prove to be a very valuable tool in well control.

(2) Well Casing

Formation pressures and fluids are isolated by the setting and cementing of as many as five steel casing strings of successively smaller diameter. Each casing string is designed with appropriate safety factors for maximum potential pressures.

Casing setting depths must comply with Geological Survey regulations. Production casing and tubing that are subjected to corrosive oil and gas are made of quenched and tempered steel, with strengths and dimensions appropriate to this type of service. Well fluids are produced through an inner tubing that isolates them from contact with the casing. In completed flowing wells, the production casing is further isolated from wellbore fluids and pressures by an annulus packer.

(3) Blowout Preventer Equipment

The blowout preventer installation is an emergency tool designed to be used in the event the primary means of well control, the drilling fluid, fails to control the well. It can be described as a large valve assembly attached to the top of the casing. In the event of an uncontrolled blow from the well, these valves can be closed to contain the blow. All drilling functions are conducted through the blowout preventers and the series of valves contained in the blowout assembly are designed to close in the well regardless of the operations being conducted.

Some of the valves are full closing, that is, they will shut in the well completely. Others will seal around any pipe in the hole and thereby close in the annular well space. One valve, called a shear blind ram, is designed so that it will shear through any pipe in the hole and close in the well.

The upper valve in the stack, an annular type, is designed to allow stripping operations. That is, pipe can be run or pulled through the valve while it is under pressure. In this way, circulation can be regained through the use of the pipe in the hole and the kill and choke lines.

The present USGS regulations require a minimum of four remotely controlled, hydraulically operated blowout preventers including at least one equipped with pipe rams, one with blind rams, and one bag (annular) type. In practice, subsea BOP's generally exceed this minimum and may consist of at least four ram types and one or two annular types.

The valves in the blowout preventer assembly are hydraulically operated and can be controlled from two or more locations and by alternate control systems. At least one of the component valves, usually the lower annular type preventer, is designed to close automatically if control pressure is lost.

The control fluid accumulator, or reservoir, is usually installed near the blowout preventer assembly, or stack, to provide minimum reaction time. In the case of offshore drilling from a floating vessel, the accumulator may be underwater or it may be on the surface vessel. Side outlets are provided in the blowout preventer body to permit circulation in case it is necessary to shut the preventers.

USGS regulations specify the minimum frequency of testing blowout prevention equipment as well as the testing range. These regulations also require new training in the operation of this equipment.

Figure 6 is a stylized version of a typical subsea BOP stack while figure 7 shows one of the largest and heaviest assemblies in use at present.

(4) Additional Control Methods

Drill pipe safety devices are maintained in the drillstring and on the derrick floor in conformance with USGS regulations.

(a) Full-Opening Drill String Safety Valve

This is maintained in the open position on the derrick floor for installation on the drill pipe to contain any unexpected flow from the well.

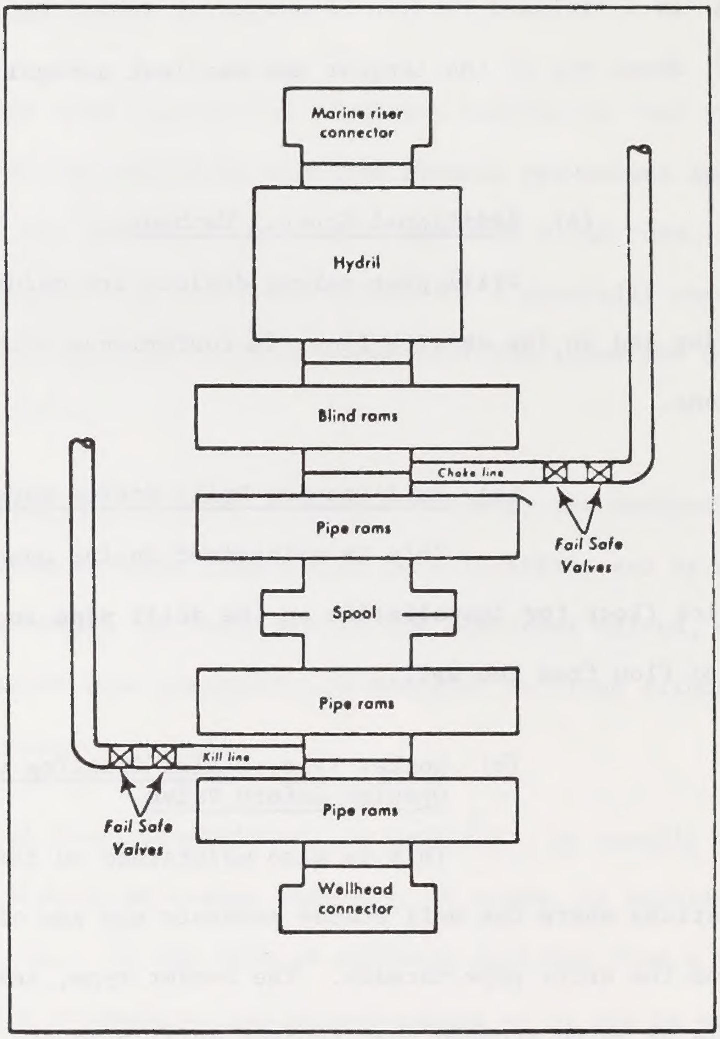
(b) Socket Type, Sealed Coupling with Full-Opening Safety Valve

This is also maintained on the derrick floor for situations where the well status prevents the use of a safety valve screwed on the drill pipe threads. The socket type, sealed coupling is capable of being dropped over exposed drill pipe and sealed.

(c) Back-Pressure Valve

A back pressure valve is maintained on the derrick floor for installation after the safety valve is installed.

FIGURE 6. Stylized Subsea BOP Stack



L. M. Harris, *An Introduction to Deepwater Floating Drilling Operations* (Tulsa: Petroleum Publishing Co., 1972, p. 99. Used by permission.)

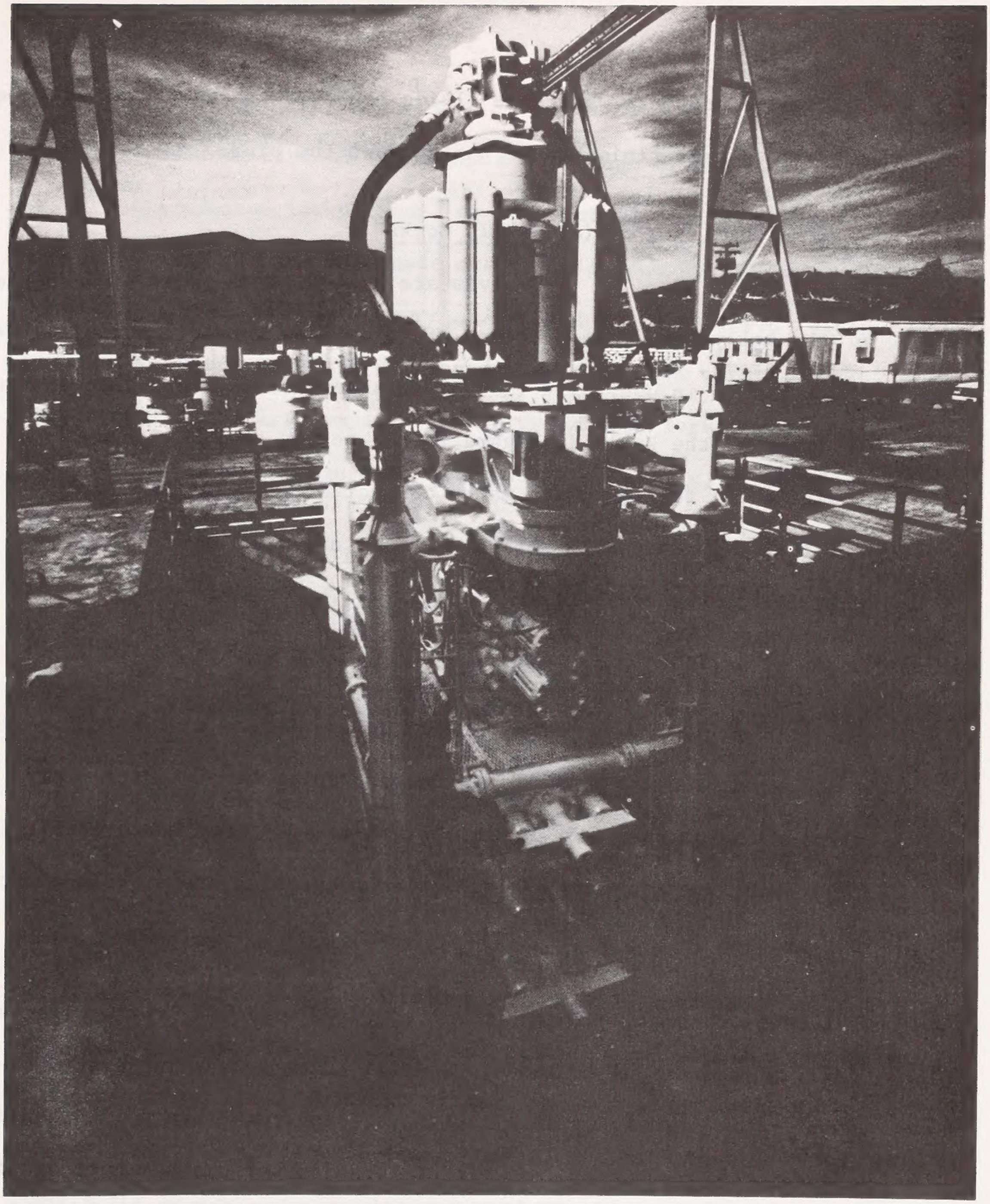


FIGURE 7. SUBSEA BOP STACK

Assembly consists of, from the bottom:

(1) Wellhead Connector
(2) Triple Ram Preventer Unit
(3) Double Ram Preventer Unit
(4) Bag Type Preventer Unit
(5) Ball Flex Joint
(6) Marine Riser Connector

Source: VETCO Offshore, Inc.

This valve prevents well bore fluids from flowing up the drill pipe, but will permit fluids to be pumped down the pipe.

(d) Kelly Cocks

Valves are installed at the top and bottom of the kelly to permit shutting off flow from the drillstring while the kelly is in use. The two valves allow access regardless of the position of the kelly in regard to the rotary table. The kelly is a square steel forging which makes connection with the top joint of drill pipe in the drill string. The rotary table turns the kelly which turns the drill pipe and bit.

e. Pollution Control

On an industry wide basis, the more stringent regulations adopted by USGS since the Santa Barbara spill have significantly reduced the chances for an accident on the OCS that would result in pollution. Regulations and pollution prevention are discussed throughout section IV.

Pollution control equipment required to be employed in floating vessel drilling operations includes: a drill cuttings washing system to assure that no oil, or drill cuttings, sand, or other solids containing oil, is discharged into the sea (hauling of oil wet cuttings to shore for processing and disposal is utilized if more practicable); drain collectors and gutters to collect all feasible oil-contaminated rig-area washdown fluids; and tanks for storage of liquid waste water until treated for disposal or transferred to a shore facility for processing. Trash and waste material is accumulated in special containers, transported to shore and hauled to an approved refuse site. Biological wastes from the crew quarters are treated and disposed of in strict compliance with Geological Survey and Coast Guard regulations. Ocean dumping of waste materials, or debris is not permitted.

f. Fire Protection

Fire protection facilities are installed in accordance with U.S. Coast Guard regulations and OCS Orders and periodically inspected as prescribed.

g. Community Facilities

The floating drilling vessel is usually equipped with a helicopter landing deck and alongside boat landings. Storage facilities are provided for diesel fuel, potable water and well drilling supplies. Crew quarters are provided. Electric power is generated onboard and auxiliary generators are maintained to provide emergency power. Continuous voice communications with nearby surface vessels and onshore are available via microwave, telephone, mobile radio, and marine radio systems. Emergency life support equipment, including gas masks, respiratory equipment, protective fire suits, life preservers and life rafts are stocked and maintained onboard to meet or exceed applicable U.S. Coast Guard regulations.

h. Drilling Operations

Drilling is normally conducted 24 hours per day, seven days per week, under the supervision of a lease operator drilling superintendent. Drilling personnel are normally transported to and from the drilling vessel by crew boats operating from nearby ports or by helicopter. Helicopter transportation is available for emergency conditions and to transport light loads of equipment and supplied during rough weather or at other times when rapid delivery is desired. Seagoing barges and/or large work boats are used to transport items such as drill pipe and well casing that are too heavy or too large for transport on crew and supply boats.

To ensure that adequate provisions have been made for safety and well control, the mud, casing, and cementation programs for each well to be drilled must be approved by the Geological Survey before a drilling permit is issued.

Well control is stressed during all phases of drilling operations. Well control drills are conducted daily until each drilling crew is thoroughly trained, and thereafter at least once each week for each crew. A specific well control procedure is developed and posted as each successive casing string is set and whenever mud weights are changed. This procedure is immediately implemented in the event of any abnormal drilling condition. Other operating practices such as blowout preventer tests, casing pressure tests, waiting on cement time, and mud control practices must be in accordance with sound drilling practices and U.S. Geological Survey regulations.

Well control training is a basic part of routine crew training. Safety meetings and well control drills are held to insure proper response from each member of each crew. The frequency of drills and crew training is also specified in existing regulations.

The USGS plans to require that there be at least two drilling rigs with deep water capability in this proposed lease sale area before issuing any deepwater drilling permits. All rigs may be actively engaged in drilling at the same time.

Should a blowout occur on a deepwater drilling well and assuming that loss of control of the well results in a blowout through or around the casing, the proven method of obtaining a kill through the drilling of a relief well would be used. Water depth in itself has very little to do with the capability or methods used to drill the relief well. The basic difference rests with the type and availability of equipment and a rig in the area of the blowout that would be capable of drilling in deep water. A rig drilling in 2000 feet of water, usually dynamically positioned with self-propulsion equipment, is capable of quick disconnect from the ocean floor well head and blowout preventer (B.O.P.). The rig can then move off the location quickly. In the case of a conventionally moored drilling vessel, provisions are normally made to slip selective mooring lines and reposition the drilling vessel away from the blowout area. The movement of the drilling vessel combined with the natural dispersal of its blowout fluids by the ocean currents in 2000 feet of water would almost certainly preclude damage to the drilling vessel. Thus with adequate back-up drilling equipment, including B.O.P. and marine riser assemblies on board or at a nearby supply point, which is usually a normal operational procedure, the rig can immediately be used to begin drilling a relief well. In the event the drilling vessel has been damaged, the other drilling rigs operating in the vicinity are called upon for assistance to drill at a relief well. This, also, has been a normal industry practice.

i. Well Completion Operations

(1) Well Testing

Fluids from formations penetrated by wells are often brought to the surface in drill-stem tests to evaluate the possibility of oil and natural gas production. These fluids are collected in tanks at the surface; drilling mud is separated from the produced fluid, and if the formation fluid is oil it may be stored for later disposition. Gas is flared in specialized, high volume burners and if there is insufficient storage space, it may also be flared.

If well tests show that commercial quantities of natural gas or oil have been found, it may be necessary to drill several additional confirmation tests before the company is satisfied that the reserves will support installation of a production facility.

(2) Abandonment

If initial tests are dry, the well is usually plugged and abandoned. Cement plugs are set to confine formation fluids in their parent subsurface formations to prevent them from intermingling and to prevent flow to the surface. During plugging operations, well control equipment remains in use. When a well is abandoned, the casing is cut off at least 5 feet below the mud line, all obstructions are removed, and the bottom is dragged to be sure that no obstructions were overlooked. In some cases, it may be necessary to drill several exploratory wells on each block before a lease is totally condemned.

Plugging and abandonment operations must be in conformance with Geological Survey regulations and such operations cannot be commenced prior to obtaining approval from the Geological Survey. The regulations specify acceptable alternate abandonment procedures for various well conditions, open hole, perforations, etc., and specify tests to ensure that formations are isolated and that the well is left in a safe condition.

(3) Producible Well Completions

If petroleum deposits prove to be commercial on a field basis, one of three courses of action in regard to an individual well may be followed:

- The exploratory well may be deemed expendable. This may be because of the well's location in regard to the projected location of production facility; because the operator is not prepared to undertake subsea completions; or because of some condition of the individual well, position on structure, mechanical condition, etc. In any case, the procedures would be the same as above for a dry-hole abandonment.

o The well may be considered useful as a future production well and be temporarily abandoned. In this case, the abandonment procedure would be the same as for a permanent abandonment as far as isolating the various intervals tested and/or left open, but other requirements of a permanent abandonment are relaxed. Annular space extending to the ocean floor may be left open, no cement surface plug is required, and the ocean floor need not be cleared. In lieu of the cement surface plug, a mechanical bridge plug is required to be set between 15 and 200 feet below the ocean floor. As in the case of a permanent abandonment, prior approval by the Geological Survey is required before commencing operations.

After the bridge plug is set, the wellhead is capped and left in condition for future entry when production activity commences. This results in the temporary existence of an underwater "stub". The Coast Guard District Commander requires that such stubs be marked by a buoy at the surface if located in 200 feet of water or less, and that the buoy be lighted if located in 85 feet of water or less.

When production facilities are ready and it is desired to put the well in production, a drilling vessel would be required and BOP's, controls and riser system would be reconnected as before. The temporary plugs would be drilled out and the completion would be made as described in section 4.e.(2).

If at a later date it was decided to permanently abandon the well, a drilling vessel would also be required to re-enter the well, drill out the temporary plugs and proceed as for a dry-hole abandonment as described above.

o The well may be considered as a future production well and the well may be completed as described in section 4.e.(2). while the drilling vessel is still on location. There may be certain modifications in the completion procedure insofar as the production wellhead assembly is concerned, depending on the operator's field development plan. That is, the complete production head assembly may be installed and the well left in a condition requiring only the connection of flow lines and the removal of the tubing plugs in order to produce. Or, perhaps only the lower portion of the production head assembly would be installed at this stage. This would leave the well closed in, requiring the installation of the upper portion of the production head assembly in addition to flow line connection and removal of the tubing plugs in order for the well to produce. The latter possibility would be particularly applicable if an encapsulated production system is planned, but could be used for other systems as well. The various subsea production systems are described in section 6.

The selection of this option in well completion operations would be based on economic considerations. A smaller, and much less expensive, vessel could be used to complete the operations necessary to put the well on production. A drilling vessel would not be required since it would not be necessary to re-enter the well.

j. Contingency Plans

The most effective method of controlling pollution is to prevent it from occurring. Prevention of pollution is a primary objective of all OCS operations, but the possibility of a pollution event always exists. Personnel would immediately activate the respective operator's Oil Spill Contingency Plan in the event of a spill or leak of oil or other pollutant. Small spills would be handled by the lease operator and supply boats in the area under the direction of the onboard lease operator supervisor. Larger spills would be handled by additional boats, equipment, and manpower under the direction of the lessee's Emergency Response Team. The Coast Guard

Regional Contingency Plan would be activated if necessary. Contingency operations are directed toward the principal goals of reducing or eliminating the source of the spill and preventing oil from reaching the shore. Detailed contingency plans have also been prepared for severe weather conditions. National, Regional and Clean Seas, Inc. contingency plans are discussed in section IV.

4. Development Drilling

Offshore development drilling has normally been conducted from fixed bottom-founded, water surface-piercing platforms similar to those depicted in figures 8 through 11 . If exploratory efforts are successful in proving a hydrocarbon reserve, production operations are initiated by installing a platform to serve as a base for drilling development wells. A number of wells may be directionally drilled to develop a large area from a single platform. Platforms in the Santa Barbara Channel area may contain as many as 60 wells. Presently, 30 to 50 wells have been drilled from each platform.

Platforms have been installed in the Gulf of Mexico in water depths to 373 feet and Shell Oil Company has let contracts to build two jacket-type platforms for installation in 1,000-foot waters in the Gulf of Mexico. Industry experts state that the technical capability exists to extend platform operations to about 1,200 feet. Platforms are now being fabricated for installation in the North Sea in water depths to 500 feet and a platform is being constructed for installation in 850 feet of water in the Santa Ynez Unit in the Santa Barbara Channel.

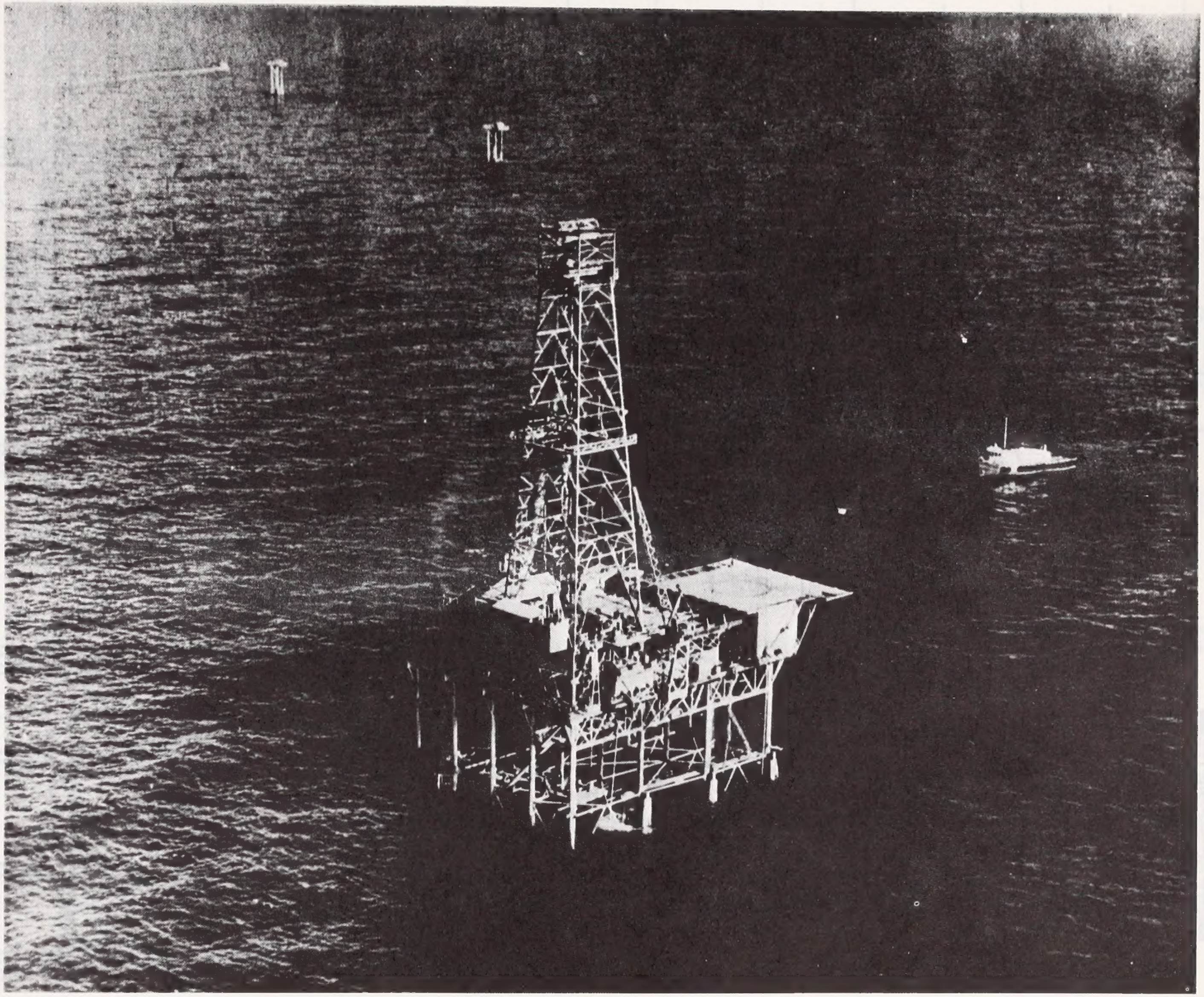


FIGURE 8. SELF-CONTAINED FIXED PLATFORM

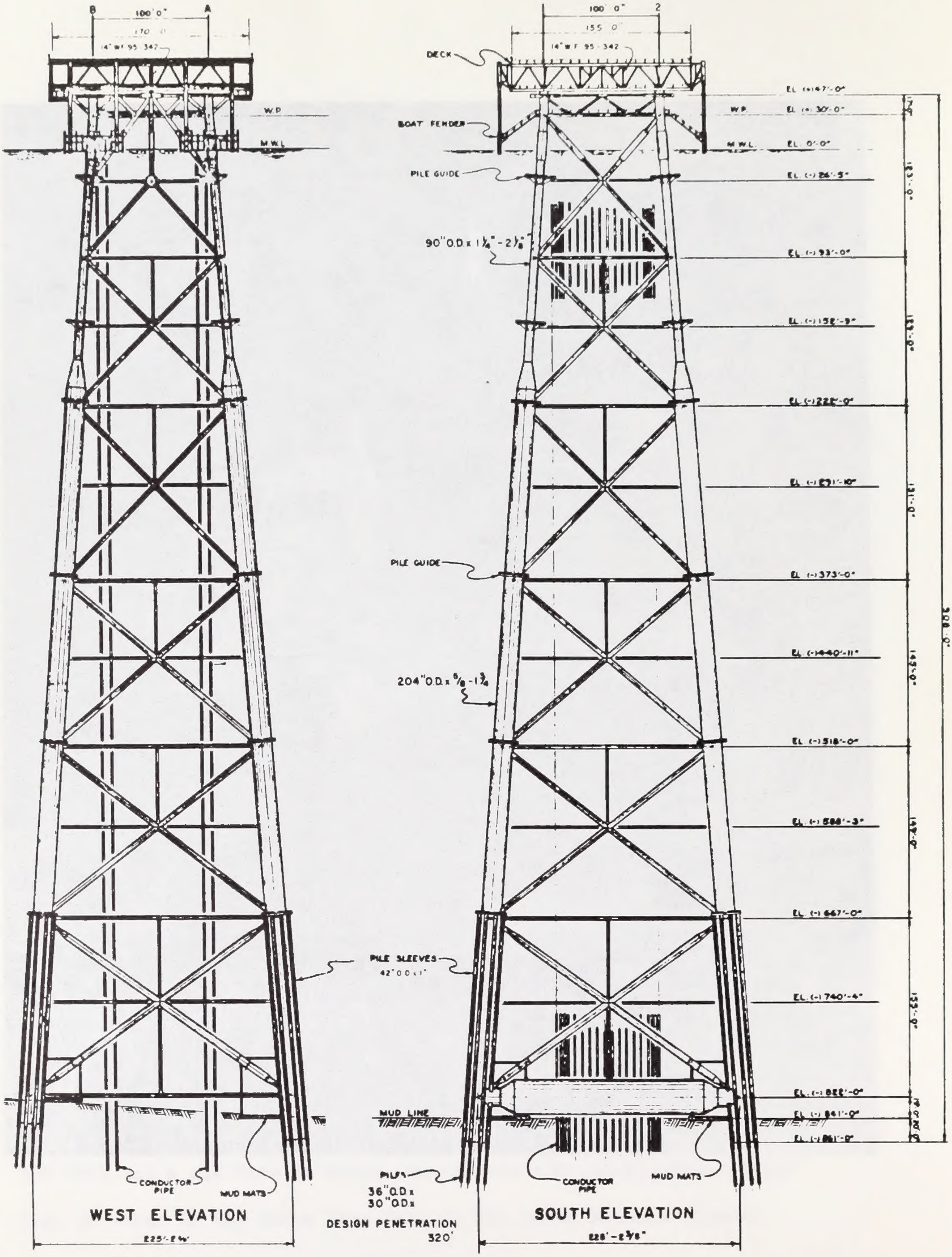


FIGURE 9. TEMPLATE PLATFORM
Source: Exxon Company, U.S.A., 1971
Supplemental Plan of Operations,
Santa Ynez Unit

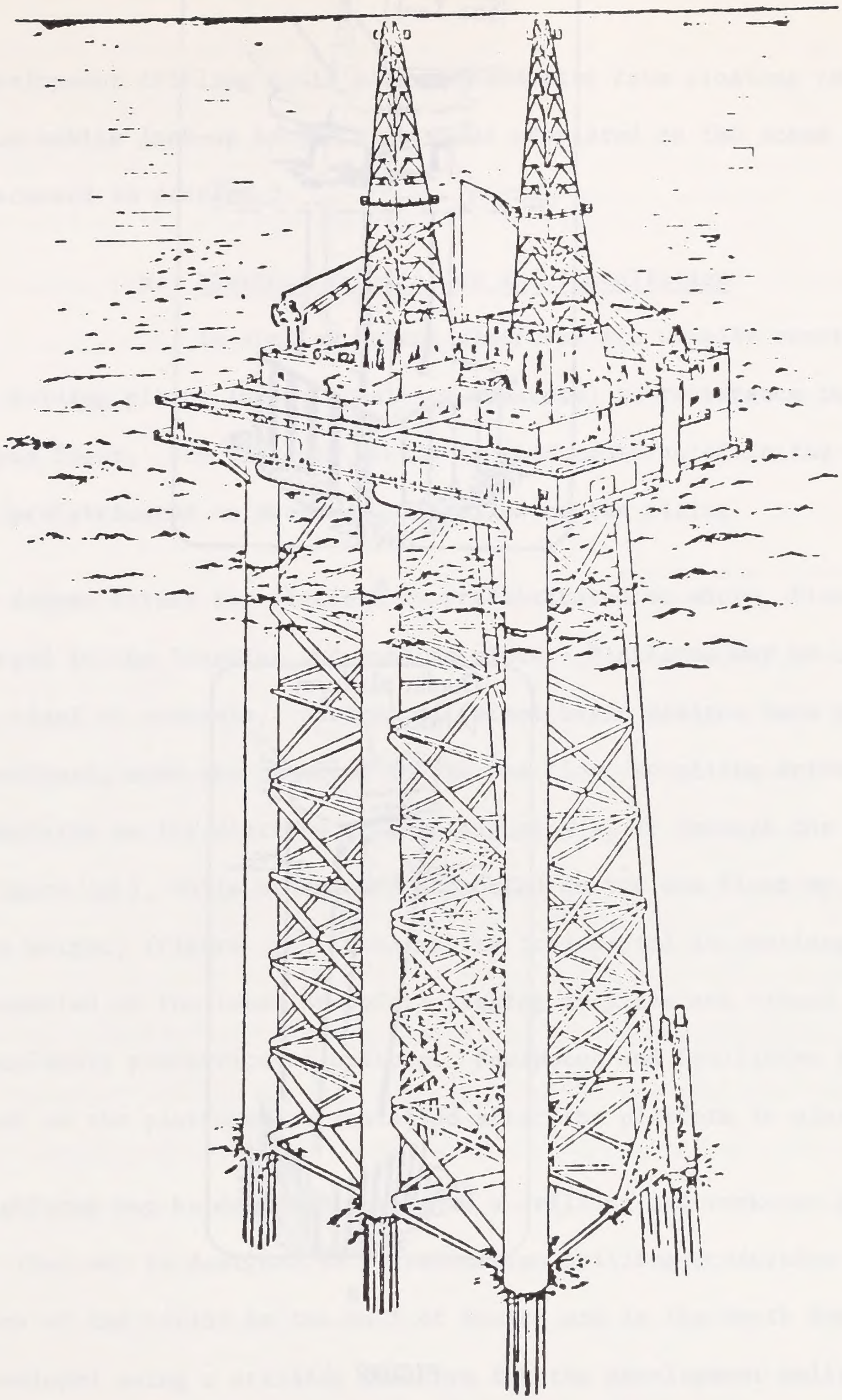
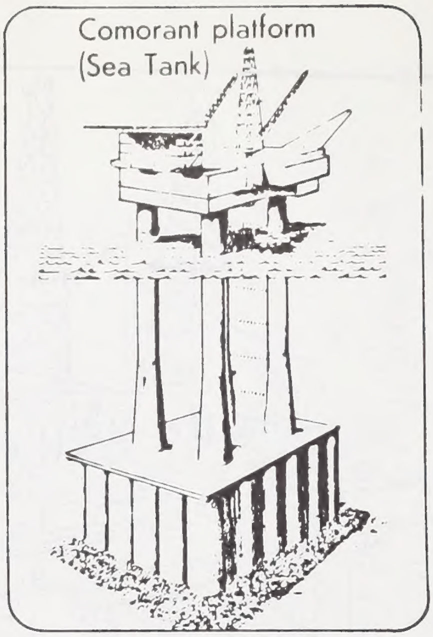
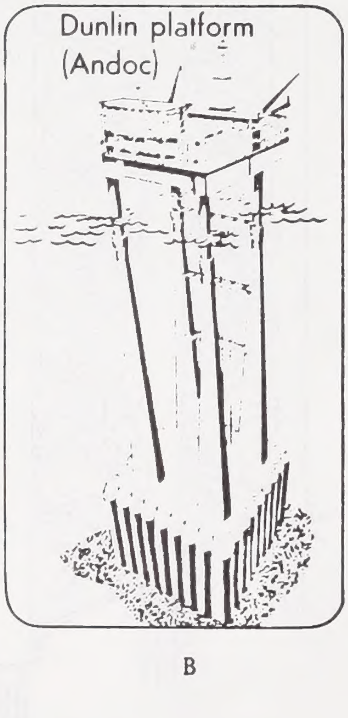


FIGURE 10.

TOWER/TEMPLATE PLATFORM



A



B

FIGURE 11.

A & B - GRAVITY TYPE STEEL & CONCRETE COMBINATION DRILLING, PRODUCTION & STORAGE PLATFORMS IN CONSTRUCTION FOR THE NORTH SEA.
From: Oil & Gas Journal, May 27, 1974, Vol. 72, No. 21, p. 34.

Development drilling could also be conducted from floating vessel or from mobile jack-up barges with wells completed on the ocean floor as discussed in section 3.

a. Platform Fabrication and Installation

In shallow waters platforms are usually constructed by driving piling (wood, steel, or concrete) to resistance in the ocean floor. The platform proper is then constructed on the piling, or prefabricated on shore and installed on the piling.

In deeper waters the platform is prefabricated on shore, floated or barged to the location and sunk in place. Platforms may be constructed of steel or concrete. Several different basic designs have been developed, some are fastened to the sea floor by piling driven through templates on the platform proper (figure 9), or through the legs (figure 10), while others are supported on the sea floor by their own weight, (figure 11). Some may be transported in sections to be assembled at the location before sinking in place and others may be completely prefabricated onshore. Equipment and facilities to be used on the platform are installed after the platform is placed.

Platforms may be designed purely as a drilling and workover platform or they may be designed as a combination drilling-production platform. Many of the fields in the Gulf of Mexico and in the North Sea are developed using a drilling platform for the development wells and a satellite platform for the production facilities. In deeper waters, particularly, the trend is toward combining platform functions since costs increase greatly with depth.

Recently, in the North Sea, a platform combining drilling and production functions with a 900,000 barrel storage capacity was set in place in the Ekofisk field. This platform, which is essentially a gaint group of concrete tanks, was prefabricated onshore, towed to the site and sunk in place. It is a gravity-type structure held in place by virtue of its geometry and weight.

The platforms shown in figure 11 are also gravity-type structures and are being constructed for installation in the North Sea in waters about 500 feet deep. Each platform is similar in size and construction methods and each will have a storage capability of about 900,000 barrels of oil in the base. They are scheduled for installation in 1976.

The Exxon platform, designed for use in 850 feet of water in the Santa Ynez Unit in the Santa Barbara Channel OCS was thoroughly discussed in the Santa Ynez Unit EIS. It will be a template-type platforms, prefabricated onshore in two sections. The sections will be towed to a protected area near the installation site, joined together, then towed to the site and sunk in place.

Platform design depends on the projected use of the platform, the water depth, and the characteristics of the sea floor at the location. A thorough investigation of the sea floor conditions, including resolution, shallow penetration acoustic surveys and soil sample analyses, is required by the Oil and Gas Supervisor, Pacific Area, before a platform site and design is approved by the USGS. No technological limitation in platform installation in water depths to at least 1,200 feet is apparent at this time, according to industry experts.

Platform construction and installation would probably require from six to eighteen months, depending on the design. A probable prefabrication site for platforms for the southern California OCS would be in the Los Angeles Harbor area, a center of heavy industrial activity.

b. Platform Environmental Design Criteria

To insure that southern California OCS platforms have adequate resistance to environmental forces and can fulfill their functional requirements, the structures and their foundations are designed to carry normal gravity and operating loads in conjunction with appropriate storm or earthquake induced forces. Earthquake and storm conditions in the southern California OCS area are described in section II.A.4. and II.B. 6.

Inasmuch as the southern California OCS is a seismically active area, the design and location of platforms must take into account the probability that moderate- to large-magnitude shocks may occur during the life of the platform. Although earthquake criteria are the most important and the controlling design factor, wave load and severe storm design criteria are also important in the environmental design criteria.

The structure should be designed to:

- Withstand safely the most severe loads that might occur during the transport to location and during installation,
- Withstand safely the loads that might be caused be severe storm waves or maximum earthquakes anticipated in the area, and
- Perform the functions of a drilling and/or production facility.

(1) Earthquake Design Criteria

Proposed structures must be designed, based on the best technology available to accommodate the seismic conditions within a given geographic area. The following general design requirements and criteria must be met:

- Criterion 1

  Structural damage must be avoided in the event of ground shaking for which there is a significant probability of occurrence during the life of the structure.

- Criterion 2

  Safety against collapse must be provided in the event of the strongest potential ground shaking (or ground shaking having an extremely small probability of occurrence); plastic straining and moderate yielding are permitted.

- Criterion 3

  The structure must have sufficient ductility to undergo plastic straining without loss of structural integrity. (This condition insures ductile behavior well into the yielding range.)

Geological Survey regulations are presently being revised and will contain more specific design criteria guidelines and requirements.

Existing and presently proposed platforms on Federal leases in the Santa Barbara Channel have all been designed in accordance with the best technology for seismic design and structural analysis available, at the time of their initiation. In view of the continuing developments in the fields of earthquake seismology and seismic design, the USGS is convening a multidisciplinary advisory panel of experts to make a comprehensive review of the seismic design of offshore platforms. All designs for future installations will be reviewed by the Supervisor in accordance with the latest recommendations of this panel.

In addition to the design criteria, the location site is carefully investigated to ensure that potentially hazardous areas (areas with recently active faults, potential slide zones, incompetent bottom soil conditions, etc.) are avoided.

(2) Storm Design Criteria

Structural member stresses must remain within American Institute of Steel Construction (AISC) allowables for severe storms that have significant probability of occurrence during the life of the structure. For this criterion, AISC allowables are derived from Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings, Seventh Edition, 1970.

Repetitive stresses arising from all storms occurring in the life of the structure must be sufficiently small as to preclude undesirable effects on the structure.

(a) Severe Storm

Standard engineering practices have led to platform designs for severe storms that have a probability of occurrence of one percent per year (a 100-year storm). This criterion was used for five existing Santa Barbara OCS platforms. However, for the proposed Santa Ynez Unit platform, a severe storm crest elevation having a probability of exceedance of one-fourth of one percent per year (400-year storm) was used for analysis purposes. (Regulations are presently being revised to contain more specific design criteria guidelines and requirements.)

The severe analysis crest elevation (400-year event) is derived from oceanographic analysis of historical meteorological data and statistical treatment of these data. The resulting severe analysis conditions are as follows:

- o Crest elevation above storm mean water level 28 ft. (wave height, crest to trough, 44 ft.)
- o Storm tide, eight feet
- o Storm wind velocity, 100 mph

Oceanographic studies of meteorological data were performed by Oceanographic Services, Inc. (OSI). A copy of this report "Storm Wave Study, Santa Barbara Channel," is contained in the Santa Ynez Unit Operator's Supplemental Plan of Operations which was submitted to the Geological Survey for approval. This study includes a hindcast of the ten storms generating the most severe sea state at each of five locations in the Santa Barbara Channel for a historical period covering the years 1899 to 1968. Standard procedures are employed to derive the extreme crest elevation.

(b) High-Cycle Repetitive Storm Stresses

Calculation of repetitive stresses from all storms to which a platform may be exposed during its lifetime requires integration of storm effects continuously with time. To make this integration practical, all sea states expected at a platform location, either frequently or as an extremely rare event, are classified into eight conditions of sea amplitude and dominant period.

(3) Other Design Conditions

During the 27-year history of oil operations in the Gulf of Mexico, industry has gained a good understanding of the physical forces acting on offshore platforms. Therefore platform design is a matter of selecting the optimum geometry and sizing structure members with appropriate safety factors to withstand maximum anticipated natural forces and operational loads. Appropriate design procedures are outlined in American Petroleum Institute (API) Recommended Practice RP 2A and various API specifications. Those guidelines were prepared to cover engineering design and operation of offshore structures and related equipment.

(a) Gravity Loads

Gravity loads for design must include all deck loads developed by the drilling and producing operations conducted on the platform as well as the dead weight of the platform itself.

(b) Piling Design and Soil Conditions

Foundation borings and detailed geological-geophysical studies are made in order to assure that the selection of a location where sediments in which the piling is founded will be stable under the largest earthquake ground shaking expected during the lifetime of the structure and to provide data for design of adequate piling for the platform.

(c) Transportation and Installation

Platforms are designed to withstand the most severe loads that might occur during transportation and installation, and to have adequate stability. The design requirements insure structural integrity under dynamic wave loads that might occur during transportation, and under impact loads that might occur during either transportation or installation. Stability requirements insure safety under tow and during installation.

(d) Corrosion Control

Platforms are protected from corrosion by coatings above mean water level and by cathodic protection below mean water level.

(i) Protective Coating

The protective coating system used is an established concept and employs only standard materials used in accordance with conventional corrosion protection practices. It has been used successfully for over ten years in the Gulf of Mexico. Three types of protective coatings are used:

- Galvanizing - applied to all hardware, fencing, handrails, and grating.
- Sheathing - synthetic rubber and monel sheathing is applied to all members in a wave zone between ELEV (-) 8' -0" and ELEV (+) 16' -0".

- Painting - a 5-coat, 14-mil epoxy or vinyl system is applied to all surface areas above mean water level not protected by galvanizing or sheathing.

(ii) Cathodic Protection

The cathodic protection system employs standard materials used in accordance with conventional engineering practices. The system is a galvanic anode system that will provide 10 ma/sq. ft. of current density for surfaces in the water zone and 4 ma/sq. ft. current density for surfaces in the mud zone for approximately 20 years. Provision can be made to switch to an impressed current system for the remainder of platform life after depletion of the galvanic system.

(e) Specifications

In accepted engineering practice, various well established specifications, codes and standards are incorporated into platform specifications in whole or in part, as applicable. Some examples of these specifications are listed below.

- American Institute of Steel Construction (AISC): Code of Standard Practice for Steel Building and Bridges. Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings.
- American Society for Testing and Materials (ASTM).
- American Welding Society (AWS).
- American Petroleum Institute (API).

- o Steel Structures Painting Council (SSPC).
- o U. S. Standards Institute (USSI).

(f) Platform Removal

Platform structures are designed to be removed at the end of their useful life. The platform wells would be plugged and abandoned, well conductors would be cut below the mudline and removed, and deck units and production equipment would be dismantled and removed. The platform pilings would then be cut below the mudline and the jacket refloated and removed.

(g) Beautification

Beautification studies have shown that under some conditions structures may be screened by the use of painted pattern designs that change their silhouette or by water spray techniques that reduce their visibility. However, the U.S. Coast Guard has expressed concern that camouflage techniques could increase the hazards to navigation. Since this is a prime consideration in platform location and design any such proposals would require very careful consideration. These studies are continuing, and promising techniques will be evaluated for use on proposed platform structures.

c. Pollution Prevention and Control

Oil, gas, water, solid wastes, and biological wastes are carefully controlled to insure that untreated or hazardous substances are not discharged to the atmosphere or the ocean. Platforms have fire detection and fighting equipment, gas detecting equipment, and safety shut-in systems in all appropriate areas. Pollution prevention and control, safety procedures, and other regulations for platforms and other components are discussed in detail in section IV Pollution prevention and safety procedures and equipment must be in compliance with all applicable regulations.

d. Community Facilities

Platforms would be equipped with a helicopter pad and boat moorings. Storage facilities would be provided for diesel fuel, potable water, and well stimulation chemicals. Crew quarters would be provided during the development drilling phase. Facilities and living quarters would be equipped and maintained in compliance with the Occupational Safety and Health Administration regulations.

Electrical power could be supplied by submarine cable from shore or power could be generated offshore. Auxiliary gas turbine or diesel generators are normally installed on the platform to provide emergency power. Microwave VHF/UHF mobile radio and marine frequency VHF marine radio communication systems would be installed to provide continuous voice communications with the onshore site and nearby surface vessels. Emergency life support equipment that meets or exceeds applicable U. S. Coast Guard regulations would be maintained on the platform. This include gas masks, respiratory equipment, protective fire suits, life preservers, and life rafts. The platform would be equipped with all of the navigation aids that are required or recommended by the U. S. Coast Guard.

e. Development Drilling Operations

As previously mentioned, development drilling could be conducted from fixed leg platforms, from floating vessels, or from mobile jack-up rigs, utilizing submerged production system completion techniques. Such wells could be drilled vertically and individually, that is on a selected spacing pattern, or they could be drilled directionally to cluster the wellheads in one location. Drilling techniques such as those already described in section 3 would be followed in either event.

When drilling is conducted from a platform, the drilling rig, power plants, generators, living quarters, storage sheds and other components, constructed in modular form, are added to the platform, and production well drilling commences. The sequence of drilling operations for production wells is essentially the same as for exploratory wells.

Typical drilling system components for either platform or floating vessel use would be rated for drilling a 9-7/8 inch hole to 16,000 feet or more. The basic drilling equipment would include: a 142-foot, 1,000,000-pound class drilling derrick capable of withstanding 125 mph winds with 12,000 feet of 5-inch drill pipe racked in the derrick; a 1,500-input horsepower class draw works capable of efficiently hoisting loads from 16,000 feet; a 500-ton class matched hook, traveling block and crown block; a 1,000-horsepower drilling fluid pump and a 700-horsepower drilling fluid pump, both capable of operating at a pressure in excess of 2,500 psi; and a minimum 800-barrel drilling fluid treating system to include dual screen shale shakers, a desander, a desilter, a degasser, a 50-barrel mixing tank, and pumps and piping to provide drilling fluid treating flexibility.

All the functions and techniques described for floating vessel drilling in section 3 are applicable to platform drilling with some exceptions. There is no need to compensate for vessel motion, well casing extends from the ocean floor to the platform and the wellhead and BOP equipment are located directly below the drilling floor, thus there is no need for riser pipe and well control functions are directly operable by drilling personnel. All of the safety features discussed for floating vessel drilling are also applicable to platform drilling and will not be repeated here.

Many platforms are designed so that the wellheads are on different levels, thus permitting a space saving staggered arrangement of the wellheads. This allows more wells to be drilled from the platform since the wellheads require considerably more space than the casing below the head.

The other features discussed under floating vessel drilling, such as pollution control, fire protection, community facilities, drilling operations, and contingency plans are also directly applicable to platform drilling.

One difference in platform drilling is in the well completion operations.

(1) Platform Well Completion Operations

If initial tests of a well are dry, the well could be plugged and abandoned as for wells drilled from a floating vessel. More likely, however, is that the well would be partially plugged back and then redrilled directionally to a more promising location.

Testing procedures would be similar to those discussed for floating vessel drilling.

When well tests indicate the well is productive, the production tubing string, or strings, is run. Well tubing is the smaller diameter pipe that is run inside the production casing string and that serves to carry well production to the surface. Tubing is generally within the range of 2 to 3½ inches I.D., depending on the wells' productive characteristics.

Tubing strings may vary in number from one to as many as three. Some wells have been completed with more than three strings, but with conventional casing and tubing installations, three is about the maximum number that sizing requirements will permit. The purpose of running multiple tubing strings is to permit simultaneous production from more than one reservoir. It is generally not good practice to commingle production from different reservoirs due to variations in pressure and other reservoir characteristics.

The tubing is suspended from the tubing hanger which is supported in the wellhead casing hanger. Generally, particularly in flowing wells, and always in multiple tubing string completions, tubing is run with a packer that is set in the casing above the productive interval. In this manner, each productive interval is separated from others and the casing, above the packer, is also isolated.

Testing procedures are conducted through the blowout preventers and tubing is also run with the BOP stack in place. When the tubing is run, the annular casing space is sealed by the tubing hanger. Temporary plugs are then set in the tubing and the BOP stack is removed. The wellhead control assembly (christmas tree) is then set in place and connected to the tubing. The temporary tubing plugs are removed through the christmas tree and the well is then in a state to produce.

Downhole completion procedures vary greatly depending on reservoir conditions. The simplest completion technique is to perforate the production casing opposite productive intervals with gun (bullet) or jet (shaped-charge) perforators. Where sand entry may be a problem, the production casing is usually set and cemented above the productive zone and a slotted or perforated liner is hung in the casing through the productive interval. The slot, or perforation, size depends on the grain size of the formation sand. Primary completion methods are discussed in Appendix Section

In many fields in California the liner is gravel packed to prevent sand entry. After the production casing is run and cemented, the productive interval is underreamed. A special drilling tool, called an underreamer, that is capable of expanding the hole diameter, is run through the productive zone. When the hole size is increased, and checked by running a caliper log (a device to measure downhole diameters), the liner is run and hung in place. Gravel, sized according to formation sand grain size and distribution, is pumped down the drill string, through the liner float shoe at the bottom of the liner and up through the annular space between the liner and the wall of the hole. The quantity of gravel required to fill the annular space is calculated using data determined by the caliper log. When the annular space is filled, excess gravel inside the liner and in the drill string is reversed out (pumping down through the casing and up through the drill string).

(2) Subsea Completions

Subsea completions differ from the above described normal surface completions only in that upon completion, the wellhead control assembly is situated on the sea floor. Completion operations are conducted through the riser pipe and the blowout preventers and the tubing is run and hung as before, and tubing plugs installed. The riser and BOP's are removed and the wellhead control assembly is run and connected.

After flowline connections are made, the tubing plugs are removed, safety valves are installed and the well is ready to produce.

There are two general types of subsea wellhead control assemblies, one is the "wet" completion where the control assembly is placed on the casing head and is exposed to the water. The valves and other controls in the assembly may be either diver operated, or controlled remotely from the surface. The other completion technique involves an encapsulated assembly that is fixed to the casing head and contains the wellhead control assembly. The capsule is equipped with an entry port that permits the connection of a personnel vehicle. Section I.G.

5. Production Facilities

Generally, production facilities are considered to mean the equipment used to bring production to the surface, deliver it to a separation facility, and to separate the production into its component parts (oil, gas, and water).

a. Producing to the Surface

(1) Natural Flow Wells

Most wells in their initial completion stage will flow naturally to the surface. The reservoir pressure is sufficiently high to support the column of reservoir fluid in the production tubing and deliver it to the surface.

(2) Gas Lift Wells

When reservoir pressures are insufficient to lift production to the surface gas may be injected under pressure down the casing. A series of valves is located down the tubing string with each valve designed to open at a different pressure. As the gas enters the tubing string through a valve the column of fluid in the tubing is lightened and the reservoir pressure is enabled to bring the fluid to the surface. Gas lift is not practical in all wells and is generally a temporary stage, being practical only so long as reservoir pressure remains relatively high.

(3) Artificial Lift Wells

Almost all wells, at some stage in their productive lives, require artificial lift to bring production to the surface. The most common pumping method is a piston type pump run in or on the tubing and connected to the rod string run inside the tubing. The rod string is connected to the walking beam above the wellhead. Through a series of gears and levers power from a motor or engine is translated to up and down vertical motion of the walking beam. These pumping units are a common sight in most oil fields located on shore, but are not generally used for offshore production due to space limitations. Either submersible or hydraulic pumps are usually used in offshore applications. The submersible pump is an electrically operated rotary pump generally run on tubing, but some models can be suspended in the casing. The hydraulic pump is a piston type pump operated by hydraulic fluid pumped down the tubing or through a separate line run alongside the tubing. Either method requires little surface space and can be used in platform operations. Some models of the hydraulic pump can be placed or retrieved from the tubing string by pumping down or up the tubing and are particularly suitable for subsea applications.

b. Flow lines

Flow lines are the pipelines used to deliver production from the individual wells to a separation facility. In the case of wells drilled from a common platform, flow lines are practically non-existent. Production from each well is directed to a manifold consisting of a series of valves by which the production from all wells connected to the manifold can be commingled and sent to the production separation facility, or individual well production can be separately directed to a test separation facility. For subsea completions the flow line could run from each well on the ocean floor to a production platform, and then up a riser to the separation and test manifold. The flow lines could also run to a subsea manifold for delivery in a common line to a separation facility or the wells could be directionally drilled from a common location to produce to a subsea manifold. Section I.G. describes various subsea systems.

Section 6 "Transportation of Produced Oil and Gas", gives a description of the methods used to lay pipelines.

c. Separation Facilities

After production is brought to the surface it must be separated into its component parts of oil, gas and water. The production is introduced to a pressure vessel where the pressure is reduced and gas is liberated from the crude oil. These vessels are called separators and, where wellhead pressures are sufficiently high, there may be more than one separator connected in series to permit gas separation at decreasing pressures for increased efficiency. Generally a production station will have a production separator, or series of separators, where the production from all wells connected to the station is handled. In addition to the production separator, a test separator is available. Flow lines from all the wells connected to the station are connected to a manifold, a series of valves that allows the flow from each well to be connected to a common production line or to the test separator line. The test separator is used to gauge the production from each well periodically and determine its status.

Some separators are called three-phase separators and in addition to separating gas, also separate free water from the oil. In other cases, an additional pressure vessel called a free-water knockout is included in the flow pattern. These vessels have a series of chambers through which the crude oil-water mixture is directed with sufficient dwell time to permit water separation.

Often, water associated with crude oil forms an emulsion which is difficult to break down. Various methods including chemical, electrolytic, and the application of heat are used to break the emulsion and separate the water. As a rule these separation methods are not used on offshore installations due to space limitations, and after primary separation the mixture is pumped ashore for treatment.

After separation the gas is introduced to the gas pipeline for disposal, perhaps through compressors if necessary. Crude oil flows from the separators to a holding tank and from there is pumped to storage. The transfer pumps may be motor driven, but when gas pressures are sufficiently high they are commonly actuated by gas pressure. The gas, after use, is returned to the gas system.

Free water, if separated at the station, is treated to reduce the oil content to less than 50 ppm and sent to the water disposal line. It may be re-injected to the formation, disposed of in the sea, or piped to shore for disposal.

Present treating facilities in the Santa Barbara Channel area reduce the oil and grease concentration to from 5 to 25 ppm. The variation in the oil and grease concentration reported by different operators for treated produced waste water is not completely due to the treatability of the waste water or the treatment method; it is partly due to the variation in analytical sample testing methods and sample preparation procedures. The Envirionmental Protection Agency and the Geological Survey recognize this problem and in the future one analytical method and sample preparation procedure will be used by all OCS operators.

As previously mentioned, production facilities may be included on the drilling platform or they may be installed on a separate, satellite platform. In either case, platform design, construction, and safety and pollution control features would be similar to thos discussed under section 4, Development Drilling.

d. Special Production System Safety Features

Produced fluids are controlled at the wellhead by control and safety devices including: dual master valves, a check valve, a fail-closed wing valve and a wellhead choke valve on flowing wells. Wellhead equipment is specifically designed for hydrogen sulfide service and maximum wellhead pressure. All components of the wellheads are designed to appropriate API specifications.

Tubing strings on flowing wells contain a subsurface safety valve. This valve is located at least 100 feet below the ocean floor and is designed to prevent flow from the well in the event of damage to the wellhead. These valves are surface-controlled, fail-close safety valves that are hydraulically operated from a pressure system at the surface. A drop in hydraulic pressure, either intentional or accidental, will cause the valve to close, thereby shutting in the well.

Future subsurface safety valves will be selected on the basis of proven performances and reliability. The Geological Survey, National Academy of Engineers Marine Board, American Petroleum Institute (API) and private industry have formed various committees to improve oil and gas operations. One of their projects is to improve standards, specifications and testing procedures for subsurface safety valves.

In the report "Energy under the Ocean: A Technology Assessment of Outer Continental Shelf Oil and Gas Operations," (University of Oklahoma Press, September 1973) the velocity-actuated subsurface valve was identified as a technological weakness. That report suggests that the replacement of these with the newer-type surface-actuated valves would resolve this problem. The following excerpt is from that report.

> Downhole Safety Devices. Although reliability data for velocity actuated downhole safety devices are limited, there are numerous indications of their inadequacy. For example, in recent major accidents in the Gulf of Mexico, 25 to 40 percent of them failed. The U. S. Geological Survey (USGS) now requires new wells to be equipped with a surface, rather than a velocity actuated, downhole safety device. However, this new requirement does not apply to wells presently producing until tubing has to be pulled for some other purpose, such as a workover, for example. This may not occur for several years, if ever. Until there is a reliable replacement for "storm chokes" that can be installed in most producing wells without pulling tubing, the "storm choke" will continue to be a problem. Therefore, the "storm choke" must be made more reliable.

It is recognized that certain Gulf Coast incidents reflect a poor subsurface safety valve performance record. However, most of these were velocity actuated valves and were in an area known for excessive sand production problems. Severe excessive sand production, as experienced in some Gulf of Mexico areas, has not been experienced in existing Santa Barbara Channel wells and is not expected in Southern California OCS wells.

All future Pacific OCS subsurface safety valves will be the surface controlled type as required by the Pacific Area OCS Orders of June 1, 1971.

Sand monitoring devices are included in the flow lines near the wellhead on wells that may produce sand to indicate excessive sand production and thus alert operating personnel before damage to valves, connections, etc. can occur. These devices are a thin-walled, hollow steel tube inserted into the flow line perpendicular to the direction of flow. The production of sand will cut out the thin steel wall of the probe and expose the inside of the device to the flow line pressures. The probe may be used only as a monitoring device or it can be connected to a pilot valve that will actuate a safety valve to shut the well in until corrective measures can be taken.

All connections and equipment from wellhead to the separators are designed for maximum anticipated wellhead pressures. Separators and other pressure vessels are equipped with high and low level automatic shut down devices in case of oil surges to the gas system or gas flows to receiving tanks. All relief valves from pressure vessels are piped to a main vent scrubber and liquid from the scrubber is pumped to the receiving tanks. The receiving tanks are equipped with level control systems and vapors from these atmospheric presssure tanks is vented to a vapor recovery system to be returned to the gas system.

All well completion and production facilities must be designed pursuant to current regulations. The platform production facilities must be approved by the USGS before commencing operations. Equipment that would be used on future platforms in the Santa Barbara Channel Area would be similar to that being used safely in current operations, and would be installed and operated in accordance with safe practices accumulated from industry experience. This experience forms the basis of USGS requirements, which give the safe practices a regulatory mandate. Requirements specify multiple, redundant controls and safety devices including safety shut-in valves, high-low pressure pilots, high-low level controls, high-temperature shutdowns, gas detectors, shielded ignitions, fire prevention and detection equipment, and pressure relief systems. Drain and sump systems are also designed to collect any spillage that might occur on the platform.

6. Transportation of Produced Oil and Gas

a. Pipelines

(1) Construction

Pipelines laid offshore are constructed and laid by several different methods, depending mainly on the size, location, intended use, and cost. One method, pipepulling, involves the use of barges and tugs to pull sections of welded pipe from an onshore launchway over the preselected right-of-way. These sections may either be dragged along the bottom or suspended by floats. There are at least three limitations to this system. First, an extensive section of shoreline, roughly perpendicular to the shore, must be available for the fabrication and launchway site; (alternatively, it is possible, although more costly, to use a launching jetty constructed from the beach out over the water). Second, the total length of pipeline that can be laid is limited. One company estimates the limit to be 100,000 feet for smaller diameter pipe. Third, the pipeline right-of-way must be essentially a straight line. The pipe pulling method is not used often for laying pipelines to OCS locations.

Offshore pipelines, particularly large diameter or long line, are usually installed using a barge specially constructed for marine pipelining called a "lay barge". This barge is a self-contained unit including all of the facilities required to join the pipe by welding, cover the weld with protective coating, and to lower the pipe into place on the ocean floor. The pipe is coated on shore and delivered to the lay barge in uniform lengths or "joints" with the ends prepared for welding. Several anchors, at least two at each corner, are used to hold the barge position. Joints of pipe are welded together on the deck of the lay barge to form a continuous length. When a weld is finished, inspected and coated, the barge is moved forward allowing the assembled pipeline to extend over the stern of the barge and to sag downward to lay on the ocean floor. A new length of pipe is added to the "forward" end of the pipeline and the process is repeated. Figure 12 shows a typical lay barge illustrating the location of the welding, coating and X-ray stations.

Making a high-quality pipeline weld requires a reasonable amount of time. Therefore to obtain rapid production, "assembly line" techniques are used allowing welding to take place at several stations simultaneously. To do this the work on the barge must take place in an almost level position. From the barge to the ocean floor the pipe will assume a double curve or "S" shape. If the pipe is too heavy or too stiff to reach the bottom unsupported, a buoyant pontoon or slide

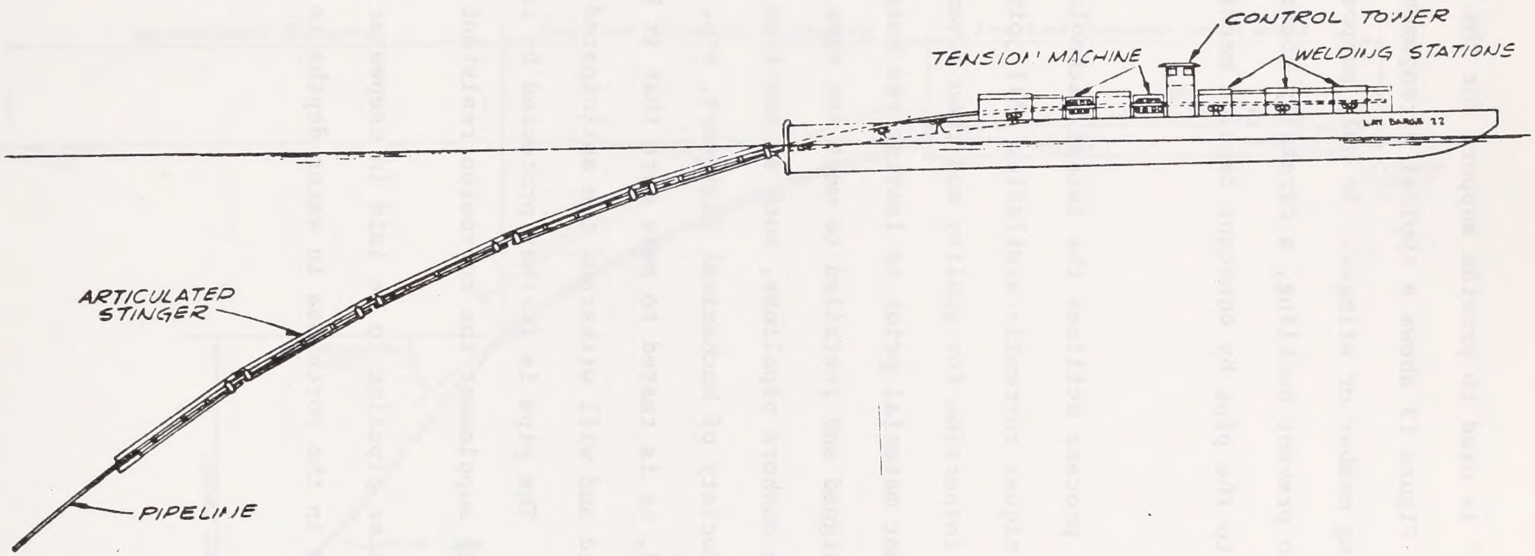


Figure 12. Lay-Barge Schematic.

called a "Stinger" is used to provide support for the upper section of the pipeline. Figure 13 shows a typical arrangement of the pipeline and supporting member or stinger. To help support the weight of the pipe and to prevent buckling, a carefully controlled tension force is applied to the pipe by constant tension machines mounted on the barge.

The pipe assembly process utilizes the latest technology and the best welding techniques currently available. All joints are given a complete X-ray inspection for quality and then covered with corrosion resistant material prior to leaving the barge. Offshore pipelines are designed and installed to meet the same codes and specifications as onshore pipelines, such as American Petroleum Inst., American Society of Mechanical Engineers, etc. After the line is completed, it is tested to make sure that it has been properly installed and will withstand the anticipated operating pressures safely. The pipe is further protected by cathodic protection systems to supplement the corrosion resistant coating.

The largest diameter pipeline to be laid in deepwater is a 32-inch diameter pipeline in the North Sea in water depths to 420 feet.

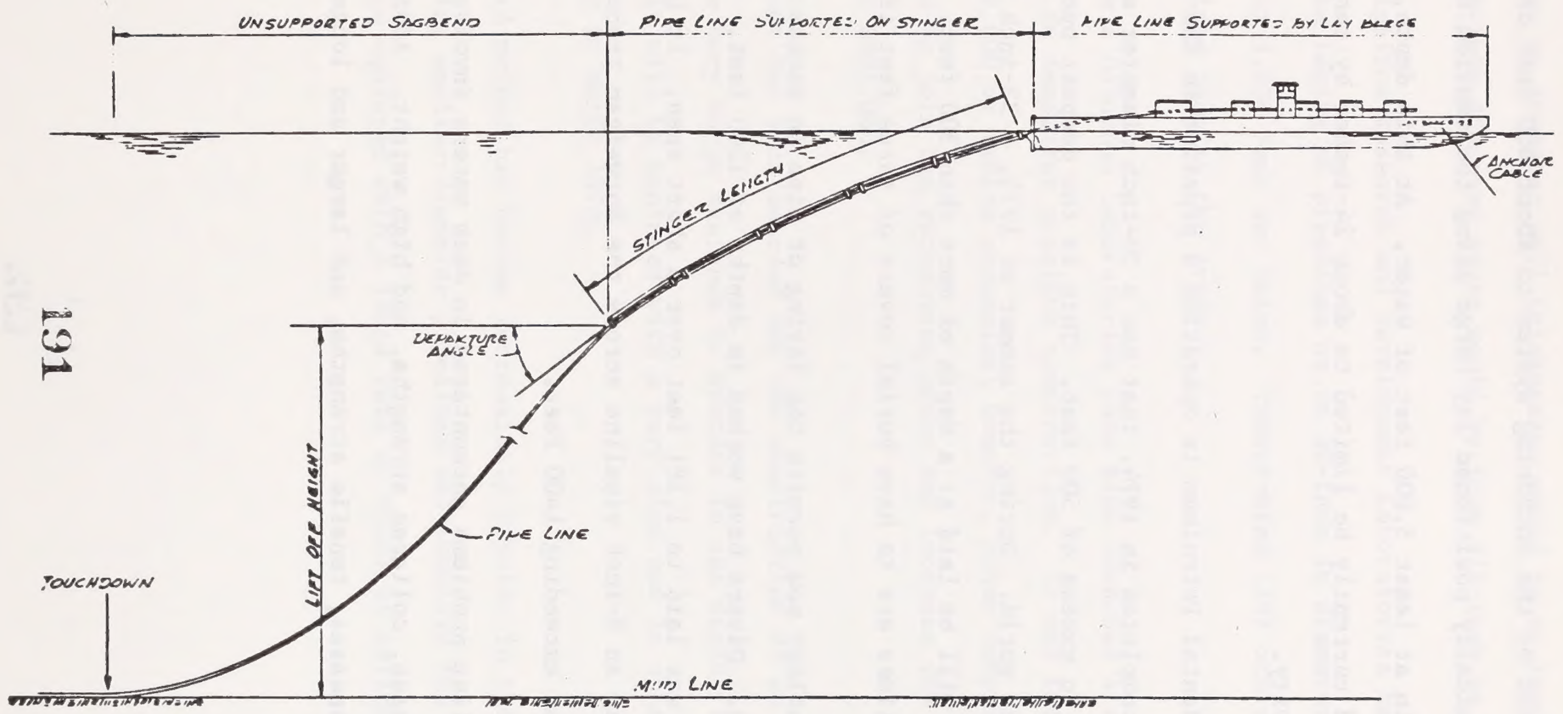


Figure 13. Schematic of Pipeline and Supporting Stinger.

Conventional and/or semi-submersible lay barges are currently limited by the anchoring system to about 600 feet of water. A dynamically positioned lay barge using the tension technique could lay in at least 3,000 feet of water. At this depth, pipe diameter would currently be limited to about 24-inches by tension machine capacity.

Occidental Petroleum is operating a pipeline in the North Sea, which was completed in 1974, that has a 30-inch diameter and has sections laid in excess of 500 feet. This is the deepest operating pipeline in the world. During the summer of 1975, a 32-inch diameter pipeline will be laid at a depth of more than 500 feet. Both of these pipelines are to have burial covers of three feet if possible.

Technology now permits the laying of pipe in excess of 1000 feet in depth. Divers have worked in depths of 1200 feet. In Italy, a pipeline was laid to 1,181 feet over a short span. It has been proposed to lay an 8-inch pipeline across the Norweigan trench, which has depths exceeding 1400 feet.

Pipeline problems encountered in deep waters involve severe bending stresses, collapse strengths, and high weight. Additional wall thicknesses, tensile strengths, and larger and longer stingers must compensate for these engineering problems. For pipelines up to 12 inches in diameter wall thicknesses would be at least ½-inch while 36-inch diameter pipes would be from 5/8-inch to 1-inch thick.

Shell Pipeline Research and Development Laboratories have under study the laying of pipelines up to 30-inch in diameter in water depths to 3,000 feet and below. Twenty-nine (29) other companies have joined them in the project.

Battelle's Columbus Laboratories have also launched a research program on deepwater pipeline construction. It was initially funded for $258,000 by twelve companies; however, other companies are expected to join the sponsoring group and increase the funding level to about $495,000.

A contract has been awarded for the construction of an offshore pipeline bury barge designed to operate in sea depths to 1,000 feet. It will be equipped with a bury sled and is scheduled for delivery in March 1976.

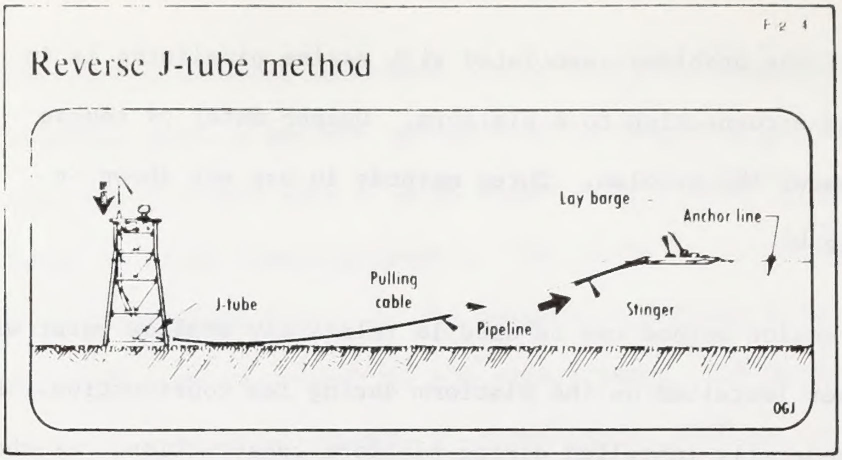
The third method has become increasingly popular in the last decade for laying smaller-diameter pipelines and involves the use of a lay-barge equipped with a large reel or spool of coiled pipe. With the reel-pipelaying technique, segments of pipeline are welded together onshore and the appropriate coatings are applied. Then the pipe is wound onto a large diameter reel which is mounted on a barge or other floating vessel. The vessel is then transported to the construction site. As the barge is towed along the right-of-way, the pipe is pulled off the reel through straightening equipment and continuous lengths of pipeline are laid on the sea floor. The reel method has several advantages. 1) With no welding and little crane work being done on the barge, the operation is much less susceptible to interruption by bad weather and high seas. A thicker-walled pipe can be used, eliminating the necessity of a concrete coating for negative buoyancy, increasing the pressure rating, and adding significant corrosion allowance. This method allows pipe-laying to proceed at a much faster rate than other methods - up to 5,000-10,000 feet per hour.

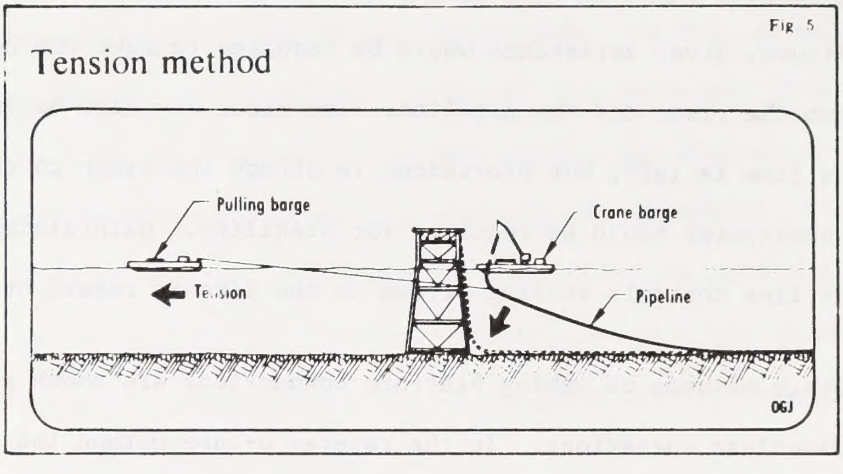
The reel method has two principal disadvantages. First, economic considerations have so far limited the diameter of the pipe that can be laid to about 12 inches. Second, during pipe-handling operations, pipe coatings are subject to occasional damage, necessitating repairs and thus, slowing the rate of pipelaying.

One of the problems associated with marine pipelining is in making a connection to a platform. Deeper water of course increases the problem. Three methods in use are shown in figure 14.

The tension method can be used in relatively shallow water with a riser installed on the platform during its construction. Risers are generally installed during platform construction. As shown in the figure, diver assistance would be required to make the connection between the riser and the pipeline. The riser may also be installed as the line is laid, but provisions to attach the riser to the platform underwater would be required for stability. Maintaining tension on the line controls bending stress as the line is raised or lowered.

Two other methods of making platform connections are shown and each are diverless operations. In the reverse J-tube method the pipe is lubricated and simultaneously pushed and pulled down the J-tube. When the pipe reaches the lay barge it can be connected to the next joint and pipelaying can continue in the normal manner. The pulling method involves pulling the pipeline from the lay barge to the platform. The pipe is fitted with a female connection and pulling tool and is pulled over a male connection on the riser. When the connection is made, the pulling tool is released and retrieved through the riser.





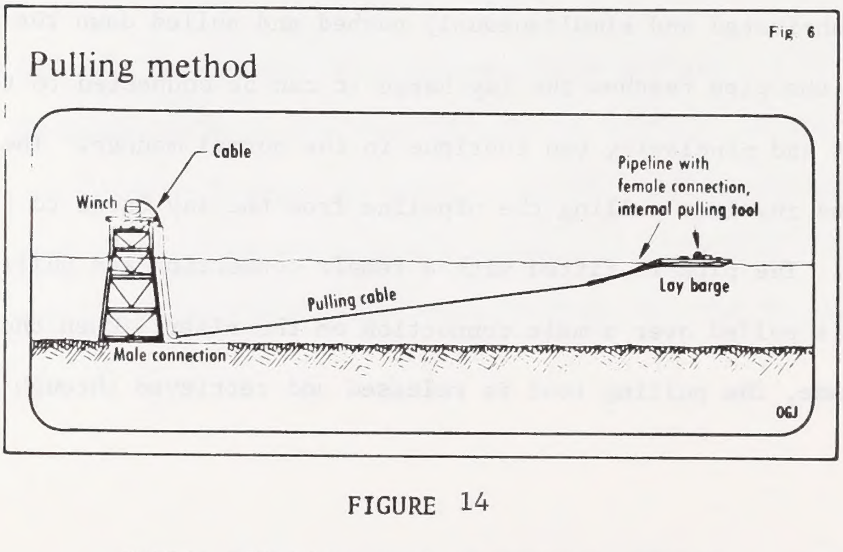


FIGURE 14

SUBSEA PIPELINE RISER CONNECTION METHODS

From: Oil & Gas Journal, January 7, 1974,
Vol. 72, No. 1, p. 43.

Considerable deepwater pipeline R&D effort is currently under way, but more is needed since pipeline costs often constitute a large portion of the cost of an offshore facility. Current attention is directed to faster "lay barge" pipe-joining methods, repair and maintenance, pipe material and design requirements for deepwater, expansion of the reel barge technique to larger diameters, and the design of risers from seafloor pipelines to floating facilities. With this and other related engineering development effort, pipelines up to 30-inches in diameter, laid in water depths to 3,000 feet appear feasible in the future.

(2) Burial

Offshore pipelines may be buried for various reasons, but the most important is the safety of the line against damage. Such damage can be caused by many factors: anchors, fishing operations, currents, suspended lengths, etc. In water depths of less than 200 feet, present OCS administrative procedures require burial of the pipelines. The minimum depth of burial is 3 ft. except in shipping fairways and anchorage areas, where the minimum depth is 10 ft. Technology exists to bury pipelines in water depths of 600± ft., for cases where such action is deemed advisable. However, one of the most effective methods of protecting a pipeline from damage due to earthquakes, is to leave the portion in deeper waters on the ocean floor surface where it can maintain as much independent flexibility relative to the surface as possible.

Conventional dredging equipment can be used in shallow water, but it is practically impossible to lay a line in a previously prepared trench in deep water. For this reason marine pipelines are commonly buried after the line is laid.

Burial is usually affected by jetting sediment away from underneath the pipeline and allowing it to sink into the resulting trench. The equipment used in this operation consists of a work barge equipped with a high volume/high pressure water pumps and air compressors. From the barge, a multiple-membered towline consisting of a strength member, water line, and air line extends downward to a U-shaped structure which straddles the pipelines and glides along it on rollers. Affixed to the U-shaped jetting device are several nozzels which direct water and air, under high pressure, ahead and below the pipeline. Sediments are blasted out of the narrow trench by water jets, partially lifted by the air and deflected to the sides by various types of fins. The suspended sediments fall diffusely along either side of the trench. As the jetting device is pulled forward, the pipeline settles into the trench and is partially buried quite soon by the reworked sediment as it slips and settles back into the depression. Complete burial and restoration of original bottom contours may require additional time. In shallow waters, experience has shown that contour restoration is quite rapid, whereas in deeper waters, more than a year may be required. The jet method is most effective in fairly soft formations, but the use of extremely high pressure, high velocity jets make the system effective in most sea floor sediments.

Saipem SpA of Milan, Italy, a contractor, has developed an underwater trencher that operates over a pipeline and uses cutters operated by hydraulic motors. Four cutters are moved by four 80 horsepower hydraulic motors and the speeds can vary to suite different bottom conditions. A water jet system is used to clean the cutter blades and to move cuttings from the trench. The trencher was tested in the Mediterranean on a hard, stiff clay bottom with a shear strength of over 2,500-pounds per square foot. It trenched at a rate of 3.5 feet per minute making a ditch approximately 8 feet deep.

Even though a buried line is protected from fluid forces it is not necessarily stable. If it is too light, it will gradually work its way up through the soil and become exposed to the water forces. If it is too heavy, it will gradually sink in the soil and impose additional tensile stress in the line. Design procedures for determining the vertical stability of the line in sands and clays have been developed and are available in the industry.

Difficulties have been experienced in burying pipe in cohesionless sands. In this case the sand will often refill the jetted trench before the pipe can settle into it. Another method, fludization of the sand, enables successful burial in this type of substrate. The powerful pumps used in the present jet systems involve such a tremendous quantity of water that it is estimated that the resulting mixture will contain an average of 1 part of solid material in 6 parts of water.

Pipelines laid to shore will be buried through the beach area, and shallow water approaches, and onshore to avoid exposure to beach erosion and to preserve aesthetic values. From this point the pipeline construction would be extended toward a storage facility or wharf facility, in turn leading to a processing facility, transport line, or refinery.

An alternative to burying the pipeline in inshore areas is to lay the pipe on the sea floor and securely anchor it in place with a cover of rip-rap (rock, concrete blocks, etc.).

Blasting may be utilized in lieu of other trenching methods in hard rock areas. The trench to bury the pipeline would be excavated by carefully placed explosive charges. This method would only be used in shallow waters where the pipeline could be placed after excavation.

(3) Pipeline Coating and Corrosion Protection

To prevent corrosion, offshore pipelines are carefully coated with such materials as epoxy compounds or thick asphaltic mastic. The coating is generally applied on shore before the pipe is delivered to the lay barge, but in some cases coating is done on the barge. In any event, as successive joints of pipe are added to to the pipeline string in the welded joint areas, normally left bare in the initial coating process, must be protected on the barge.

Lines are protected from electrolysis by both impressed-current systems and by sacrificial anodes (zinc is commonly used). These are back-up redundancies in case of damage to the primary coatings. Corrosion prevention measures are required by 49CFR Part 195.

If extra weight, or mechanical protection, is required, the pipe is also covered by a layer of dense concrete. This is applied over the corrosion protection material at an onshore location. The thickness of the coating depends on the weight required to sink the pipe and often weighting material is added to increase the density of the concrete. The concrete is generally jetted onto the pipe while the pipe is rotating and usually the concrete is reinforced by a wire cage around the pipe. In order to increase flexibility, the concrete may be partially sawn through at intervals along the pipe joint. Various curing methods are used to ensure that the concrete is completely set up prior to delivery to the lay barge.

(4) Operation and Maintenance

The safe operation and maintenance of a pipeline system requires several redundant monitoring systems to ensure the integrity of the line and detect leaks. The primary leak-detection system in use (required on all lines built after March 31, 1970 by 49 CFR Part 195.404 and 195.408) is a set of automatic pressure-sensing recorders on both ends of each pipeline system, and is essentially a safeguard to prevent the escape of large volumes of oil due to catastrophic line break. These recorders are equipped with a built-in alarm system which either shuts down the flow automatically or sounds an alarm to alert personnel of an abnormal pressure level. In this way, a leak of substantial rate is detected.

immediately. This system is insensitive to leaks which do not produce a decrease in line pressure greater than 300-500 psi.

The second system of leak detection is the routine patrolling of the offshore pipeline routes by boat or aircraft, and onshore by wheeled vehicle or aircraft. A minimum patrolling frequency of intervals between inspections of transmission lines not exceeding 2 weeks is required by 49 CFR Part 195.412. This type of monitoring would result in the detection of all sizes of leaks. The Pacific Region OCS Orders require that oil pipelines (flow lines) from platforms to onshore facilities be inspected a minimum of once each week by aircraft or boat, but in actual practice is normally performed more often. The appeal of a system of regular pipeline patrolling is that it allows detection of small leaks and therefore complements the pressure-sensing system described above.

The third system for leak detection consists of a series of volume-recording flow meters, on either end of a pipeline system. Because nearly all crude oil moves from OCS areas to shore by common carrier lines, it must be metered in the offshore pipeline gathering system and again at the onshore pipeline terminal in order that each producer be properly credited for his share of the common stream. This flow monitoring system has been designed so that the flow sensors continually indicate net input and output in real time so that attendant personnel are able to discover a decrease in output and alert appropriate stations of the possibility of a leak. This type leak detection system is required for oil pipelines (flow lines) from OCS platforms to shore (OCS Order No. 9).

All major pipelines would include remotely operated mainline block valves at intervals in order to allow isolation of segments of the pipeline. This is an industry standard and therefore "voluntary"; however, most companies operating pipelines subscribe to American National Standards Institute (ANSI) and would be expected to follow these recommendations. The pipeline requirements in OCS Order No. 9 apply only to pipelines (flow lines) from OCS platforms to shore. The Geological Survey would require any block valves deemed necessary for this type pipeline (flow line). The table below shows the relationship between the diameter of a pipeline and the volume contained per mile of line.

Length/Volume Relationship of
Line Pipe

Size (inches) ID	Length Required to Hold 1,000 bbl. (miles)	Barrels Per Mile of Line
2.067	45.6	22
4.026	12.0	83
6.026	5.3	189
8.071	3.0	334
10.020	1.9	515
12.090	1.3	750
24.000	0.3	2954

Such block valve systems, usually built on a pipeline connection platform, besides improving security in case of line breaks offer a means of access to the lines for repairs, for connection of additional lines, etc. An underwater-pipeline platform has been installed in 140 feet of water in the Gulf of Mexico by Transcontinental Gas Pipeline Company.

All pipelines to be installed will be designed in accordance with all applicable regulations; Department of Transportation, Army Corps of Engineers, California State Lands Commission, and Geological Survey regulations (OCS Order No. 9). The USGS will consider the design and installation methods before approving a permit to install any pipeline.

b. Barges

Production barges are occasionally used in offshore work, primarily for testing wells. In this case they are equipped with separation equipment and include facilities for oil storage.

Barges could be used as interim storage facilities for crude oil before pipelines or permanent storage facilities are installed.

Another possible use for barges would be the transport of crude oil from the more remote areas to a refinery center. In this case the crude oil to be transported would have water and gas removed. The maximum anticipated sizes for the vessels that would likely be used are 25,000 to 30,000 dwt. A 25,000 dwt tug/barge unit would be approximately 500 feet long with a beam of 90 feet, a loaded draft of 31 feet, and a capacity of about 175,000 barrels. The 6,000 horse-power seagoing tug would have a length of about 150 feet, a beam of 40 feet, and a design draft of 21 feet. It is anticipated that crude oil would be delivered to one or more of the numerous refineries and terminals in the Los Angeles and Long Beach harbor area. Additional facilities may be required for handling these transport vessels.

All barges and equipment aboard would conform to applicable Coast Guard and Geological Survey regulations.

c. Tankers

Tankers may be used to transport crude oil to refineries on the West Coast from some of the more remote tracts. The restrictions on the sizes of tankers which might be used would depend on loading facility capability and depth of harbors near refineries. The use of tankers will be more likely if near-shore loading terminals utilizing the single point storage mooring buoys and vessels are used.

d. Storage Facilities

At least in the initial stages of production from an offshore field, offshore storage may be provided by barges or tankers moored near a production facility and receiving the production from the facility. Mooring facilities could be simple following normal vessel mooring procedures, or they could be more complex as discussed in section 8 . If permanent floating storage facilities were considered, these more elaborate procedures would undoubtably be followed.

A possibility exists that offshore bottom-founded storage facilities could be used.

There are four large capacity seafloor crude oil storage tanks in operation. One is located in the North Sea and three are in the Gulf of Arabia off the coast of Dubai.

Phillips Petroleum Company installed a 1,000,000 barrel capacity tank in 1973 in the Ekofisk Field in the North Sea in 230 feet of water at a cost of $27 million. Continental Oil Company has installed three 500,000 barrel capacity tanks in 1969 and 1972 at Dubai in 160 feet of water at a cost of $8.5 million each.

There are twelve high capacity storage tanks for the North Sea on order or under construction. The first of these should be installed in 380 feet of water for Mobil Oil Corporation in the Beryl Field in the summer of 1975.

Construction of the North Sea storage tanks is entirely of concrete whereas the Dubai tanks are composed of a bottom concrete rim and a steel upper portion.

The advantages of concrete construction are ease of fabrication, lack of corrosion problems, lower cost, higher weight which gives firmer anchorage on the seafloor; and, a higher safety factor against catastrophic rupture.

The construction process requires a large seashore site which can easily be flooded allowing the tank to float for towing to deeper water. The concrete tanks are constructed in two phases. The lower portion is built at the seashore location after which it is towed to deeper water where construction is completed.

Operation of these tanks involves the displacing of the contained oil with seawater when offloading to tankers and displacing the seawater in the tank with crude oil production when filling.

Many technical problems of large proportions in the construction of large concrete storage tanks have been overcome in a short period of time. Large concrete structures such as these will invariably develop minor cracks which are impossible to prevent, but because of crystalline growth of free lime and post tensioning of the reinforcing steel, the cracks are self healing. It is also noted that concrete is permeable to seawater and is an important consideration when using it for this purpose. For long life concrete structures in seawater, measures should be taken to prevent corrosion and weakening of the steel reinforcing and spalling of the concrete.

Good quality control of the cement and aggregate plus the use of the proper additives in conjunction with the correct fabrication techniques can minimize these problems.

Depths for storage tanks presently in operation and under construction range from 160' to 460'.

Technology indicates designs are being prepared for installation of sea bottom storage tanks at depths of 600 to 3000 ft. Available technical literature does not contain the costs of such tanks.

Technical literature available does not indicate whether or not oil-to-water interface can be avoided. Discharge of contaminated ballast is avoided by treating the discharged water at the Ekofisk installation.

The risk of rupture of an underwater storage tank must be calculated from data including historical seismic data of a particular location involving such parameters as proximity to active faults and the history of ground movements. The risk also involves the strength of the structure and its ability to withstand seismic movement. Seismic generated forces applied to a concrete structure greatly exceed those forces of storm waves necessitating additional design considerations.

Available technical literature does not contain information concerning the cost of segregating ballast in a floating storage system.

Experience gained in storage mooring has led to improved techniques in this operation with minimizes risk of failure. Risk of collision is minimized at Dubai by standby tugs for use in event of a tanker losing control.

(1) Ekofisk Storage Tank

This concrete structure is of cellular design comprising nine vertical cylindrical tanks surrounded by a perforated breakwater wall, a total weight of 215,000 tons. It is located in a water depth of 230 feet on a seabottom composed of 75 feet thick bed of fine sand overlying hard clay. It is held in place by the force of gravity. In addition to its use as a storage facility it is used as a platform for a number of technical facilities.

It has successfully withstood several severe storms, one of which contained wave heights equal to 90% of the wave height of 100-year storm. The structure settled 25 cm. during the first year of installation. It is now expected to settle at the normal seafloor settling rate.

Seawater displaced into the sea when filling operations are underway is treated in the same manner as the produced water to reduce its oil content to less than 25 ppm. Phillips estimates the annual oil spill from the tank at 50 tons.

Recent improvements made in the buoy system used for loading tankers have given greater reliability to this operation.

(2) Dubai Storage Tanks

These bottomless tanks are composed of a circular concrete ring above which is a steel wall tapering inward toward a neck, much the same shape as an inverted funnel. They are anchored to the seafloor at the depth of 160 feet by 36 grouted-in pilings. The seafloor is made up of a few feet of sand or mud overlying a partially cemented Clastic limestone. The necks support platforms containing production and loading facilities.

The most severe weather conditions encountered have been winds of 60 mph and seas of 25 feet.

Operation of the tank is similar to that of the Ekofisk tank except that the displaced water is discharged through holes around the periphery of the rim directly into the sea without being treated. Discharged along with the seawater is about 12,000 B/D of produced water which settles out of the crude oil through use of chemical treatment in the production system. Extensive tests in 1974 showed that oil content of the displaced water was below pollution levels. The high velocity flow of the displaced water through the exhaust holes has scoured the sea bottom around the tank forming deep holes in which large fish accumulate. Problems were initially encountered in over filling. The Continental Oil Company now believes tanks with bottoms would present better control and help alleviate this trouble.

The mooring and loading operations of tankers has profited by earlier experience and good improvements have been made. Risks of collisions of tankers with the facilities are minimized by the presence of standby tugboats for use in the event a collision is imminent.

(3) Tanks Under Construction

Most of these storage tanks are of the same general design.

The Mobil Beryl Field tank is of the concrete gravity anchored type containing a cluster of 16 vertical cylindrical tanks with three pillars extending above supporting a steel platform. It will be used for storage, drilling and production. Storage capacity is 900,000 barrels and it will be installed in a water depth of 380 feet. Forty well slots are included for drilling and these will probably be supplemented by the drilling of other wells using subsea completions.

The Shell/Esso Brent Field tank should be the next installation. This tank is identical to the Mobil Beryl tank except for larger vertical dimensions. It will be located in a water depth of 460 feet. Costs of these tanks are expected to be about $27 million each.

Operations of these tanks employ the same displacement method as the others but available technical information does not state whether or not the displaced water will be treated to reduce its oil content before discharging it into the sea.

7. Treating Facilities

Treating facilities, whether installed onshore or offshore, require generally the same equipment and processing. Disposal of gas, in a practical manner, requires transport by pipeline to shore at some point, so it is doubtful if offshore gas-treating facilities would be considered. The installation of other treating facilities offshore would depend to a large extent on the nature of the production. For example, if produced water forms an emulsion with the crude oil that is difficult to break, it is doubtful that the use of expensive offshore space required for heater-treaters and/or electric dehydrators could be justified. Similarly, if produced water was to be reinjected, or disposed of to the sea, the size of the facility required to produce water of sufficient quality for either purpose would determine the practicality of an offshore facility.

A choice between offshore and onshore treating facilities would therefore be largely based on environmental and economic consideration. Factors influencing the decision would be water depth, platform cost versus pipeline cost, the type of platform (floating versus bottom founded), and the overall development procedure for the area. An important consideration in the development procedure would be the means of delivery of crude oil to a refinery; pipeline, offshore tanker loading, etc.

Any offshore treating facilities would necessarily be constructed and operated in conformance with all applicable regulations in a manner similar to drilling and production vessels or platforms. The necessary State and local approvals (i.e. Coastal Zone Commission) would be required for onshore facilities.

a. Oil Handling

After initial separation at an offshore production facility (see 5.c.) an emulsified mixture of crude oil and salt water passes to an inlet surge tank. The produced oil and water would be treated by previously treated oil or another heating fluid in heat exchangers, and would then flow to electric treaters. The treaters would separate the oil and water, after which the oil would be returned to the heat exchangers to be cooled, and the water would be piped to a dirty-brine storage tank. The treated crude oil would be additionally cooled by an air cooler and then stored in tanks at atmospheric pressure. The oil would be pumped from the storage tanks through pipelines to a marine terminal for transport to a refinery.

Treating of crude oil would be accomplished in a system totally closed to prevent vapor emissions. The crude oil would be degassed at atmospheric pressure. The treater operating pressure would be approximately 75 psia and at a maximum operating temperature of 180° F, there would be no vapor evolution. Special cone-roofed tanks with internal floating roofs and a vapor recovery system have been designed to minimize vapor evolution from the stored crude oil and prevent vapor emissions to the atmosphere. All vessels and tanks would be equipped with vent, relief, or blowdown lines routed to a vapor incinerator. (See figure 15).

b. Water Handling

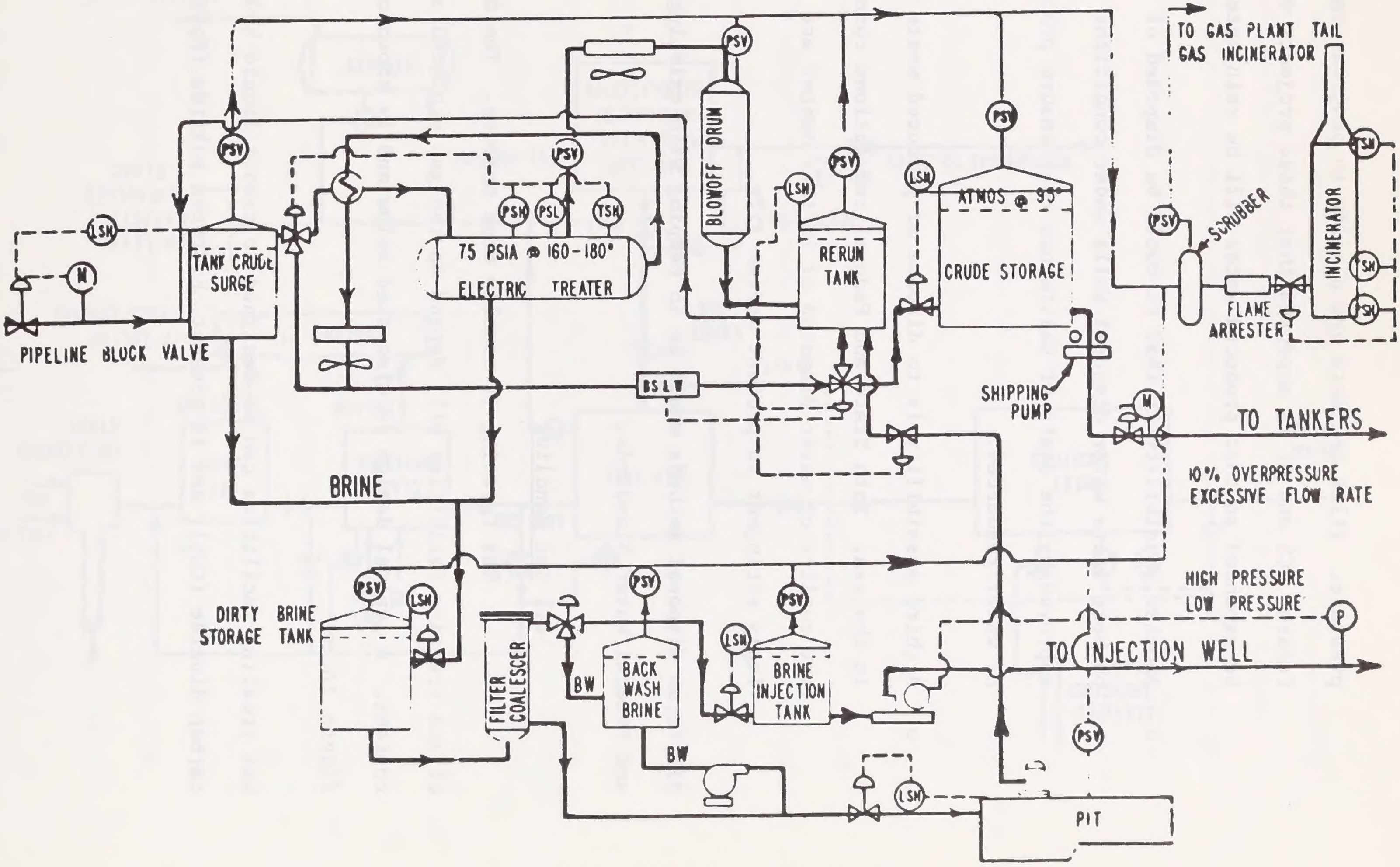
Separated salt water from the inlet surge tank and the electric treaters would flow to a dirty-brine storage tank. Free oil would be skimmed off in this tank, and the water would be pumped to a filter-coalescer or similar device. Coalesced oil would be drawn off to a settling basin. Present treating facilities in the Pacific OCS area reduce the oil concentration to from 5-25 ppm.

The produced water may be disposed of in three ways:

- The preferred method would be to return it to the reservoirs from which it was produced where it would aid in maintaining reservoir

FIGURE 15.

OIL TREATING & STORAGE



WATER TREATING & DISPOSAL

pressure. Pilot projects are already in progress on Federal OCS and it is expected that these projects will be expanded so that produced water will be reinjected.

- Another possibility is that it could be disposed of in onshore waste water disposal wells under conditions approved by the State of California that ensure protection of water resources.
- A third possibility is to dispose of produced waste water in the sea. Both State and Federal regulations concerning the quality of water disposed of in this manner are increasingly stringent to protect marine life.

All three disposal methods would be in keeping with existing State and Federal Water Standards.

c. Gas Handling

Gas treating is usually done onshore. The design of gas treating facilities will depend on the gas produced and its content. A typical design is discussed below and is shown on figure 16.

Gas treating facilities can be designed to remove liquid hydrocarbons, carbon dioxide (CO_2), and if present, hydrogen sulfide (H_2S) from the

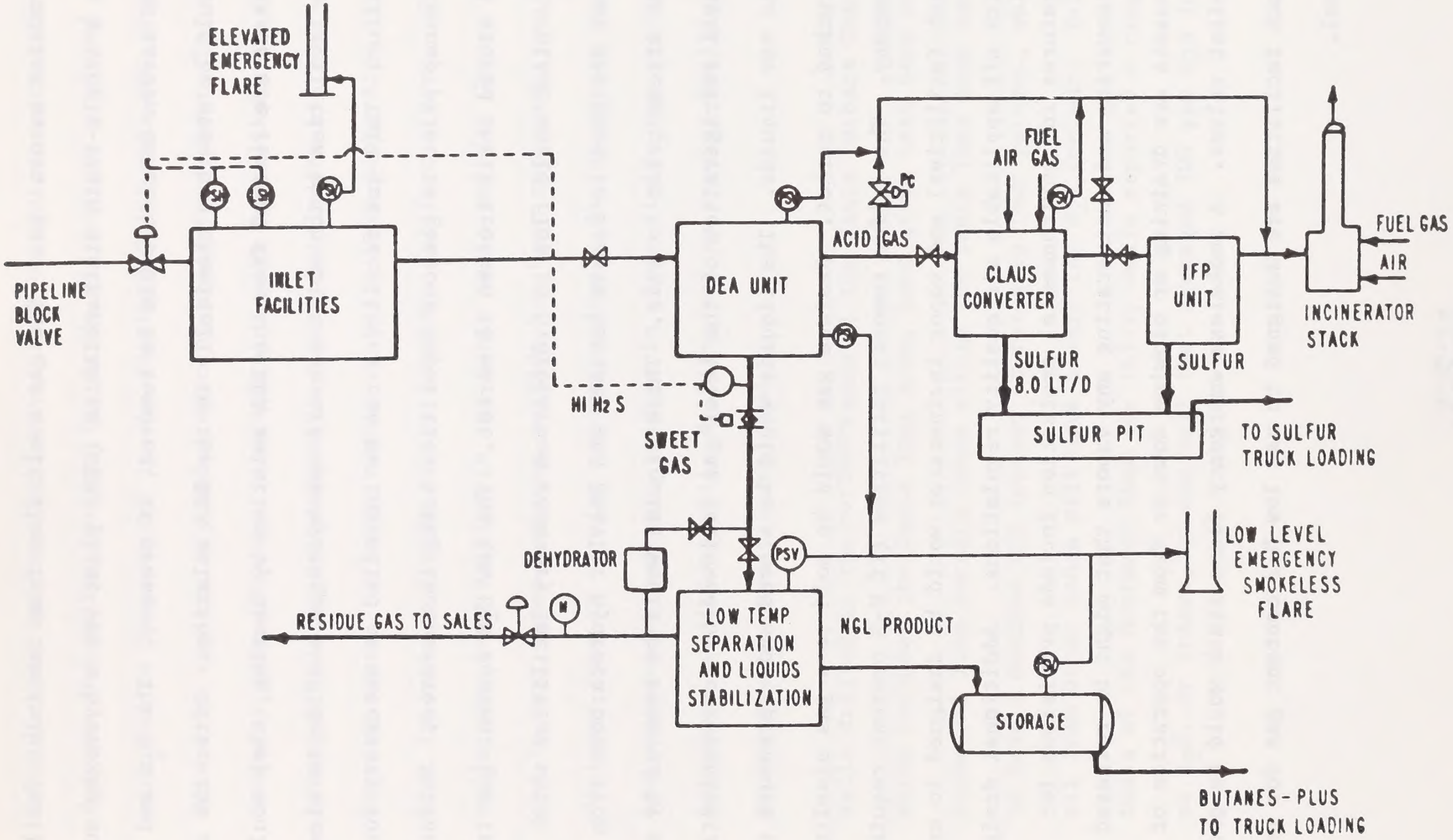


FIGURE 16.

TYPICAL GAS TREATING FACILITIES

produced natural gas. The gas would flow from the inlet facilities to a single-train diethanolamine (DEA) plant where hydrogen sulfide and carbon dioxide would be removed, if present. The H_2S and CO_2 would be absorbed chemically in the DEA solution. After the absorbed gasses are removed from the DEA solution by heating, they would flow to facilities which would convert the hydrogen sulfide to elemental sulfur. Tail gas facilities can be installed as necessary for final cleanup prior to gaseous impurities being incinerated. Sulfur could be stored until trucked to market. The low H_2S content gas from the DEA plant would flow to hydrocarbon recovery facilities which have been designed to remove butanes and heavier hydrocarbons from the gas stream prior to sale. These liquids would be removed by mechanical refrigeration of the inlet gas followed by depropanization of the raw liquids. The liquids would be stored under pressure until trucked to market. Residue gas would be sold to a gas pipeline company. The sulfur removal facilities (if H_2S content required such facilities) and vapor incinerator would be designed to comply with all applicable air quality regulations. Additional design features for environmental protection include provisions for recovering and incinerating any vapors that might be released while vessels are draining or blowing down or from the operation of safety relief valves. A smokeless emergency flare stack would be provided. Such facilities are designed to use low H_2S content gas for process fuel.

Considerable information is available on the concentration of H_2S gas and sulfur content for crude oil and gas produced or expected to be produced in the Southern California OCS area. Data from exploratory and producing wells have shown that the Monterey Zone (Miocene reservoirs) is the most likely to contain hydrogen sulfide in measurable quantities in the hydrocarbon bearing zones. A large number of wells have penetrated the Monterey Zone in onshore fields of the Southern California Area. Over 500 wells have been drilled in the Santa Maria and Cat Canyon Fields, and in many cases hydrogen sulfide has been reported from the Monterey Zone in varying concentrations. As far as can be determined, the presence of hydrogen sulfide in these fields has presented no hazardous conditions while drilling and no special drilling or producing equipment is employed.

Wells drilled in the northern area of the Santa Barbara Channel, which includes the Santa Ynez Area, have given test data to show that crude oil from certain zones within the Santa Ynez Area can be expected to have a maximum H_2S content of three to four percent, while crude oil from other zones will have a very low H_2S content. Drill stem tests of the Monterey Zone for thirty wells reported a range from no H_2S, or traces, to one well that averaged 300 ppm H_2S in the samples.

The middle portion of the Santa Barbara Channel includes the Dos Cuadros and Carpenteria Areas with producing fields. Tests made on producing wells have shown no significant concentrations of H_2S for productive leases in this area. Analysis of gas streams made from all five production platforms in this OCS area have given measured concentrations of H_2S ranging from .02 ppm to 50 ppm. The maximum measurements shown were obtained from single wells with the highest H_2S concentrations. Recent tests made on one lease with ninety-six wells indicated only six wells with H_2S content in excess of 20 ppm and a maximum of 50 ppm. These tests were made in the raw gas stream with no dilution. This lease has had ninety-six new wells, numerous redrilled wells, and over 400 pump changes and/or remdeial jobs have been conducted with the complete absence of any H_2S in harmful quantities.

The southern area of the Santa Barbara Channel includes the Hueneme Area where several exploratory wells have been drilled. The only measurable quantities of hydrogen sulfide was encountered in the Monterey Zone. A wet gas analysis from a drill stem test of the Monterey Zone in one well recorded a hydrogen sulfide content of 160 ppm, which is the highest concentration found to date at

Hueneme. No unusual precautions were taken to protect against hydrogen sulfide when drilling and no problems have been experienced as a result of hydrogen sulfide. In view of the information available from wells drilled at Hueneme and the known conditions and low concentrations of hydrogen sulfide in this area, it is considered that any risks of adverse effects from hydrogen sulfide in proposed drilling and producing operations will be minimal. Production information to date shows that the H_2S content is low (less than 0.1 percent) for all existing producing horizons in the Santa Barbara OCS.

The available information from exploratory and development drilling, production history, and geological interpretations of both onshore and offshore areas, indicates that no undue adverse conditions due to hydrogen sulfide should be anticipated for operations in Southern California OCS Areas. Special instructions and contingency plan requirements for operations in an H_2S environment or where H_2S may be encountered, are being incorporated in a recent revision and amendment of OCS Order No. 2 for the Pacific Area. This amendment will supercede a USGS Notice to OCS Lessees and Operators containing these H2S requirements, issued on August 26, 1974.

8. Offshore Loading Terminal

Offshore loading terminals are a possibility for shipping oil as they may be safer and more economical than onshore docking. They also permit the use of larger tankers, but larger tankers will probably not be a consideration in this area since it is expected that all production will be utilized, if not locally, at least domestically. There are presently seven nearshore loading terminals in the Santa Barbara Channel area. A significant increase in Pacific OCS production would require the consideration of adding new terminals or the modification of existing ones.

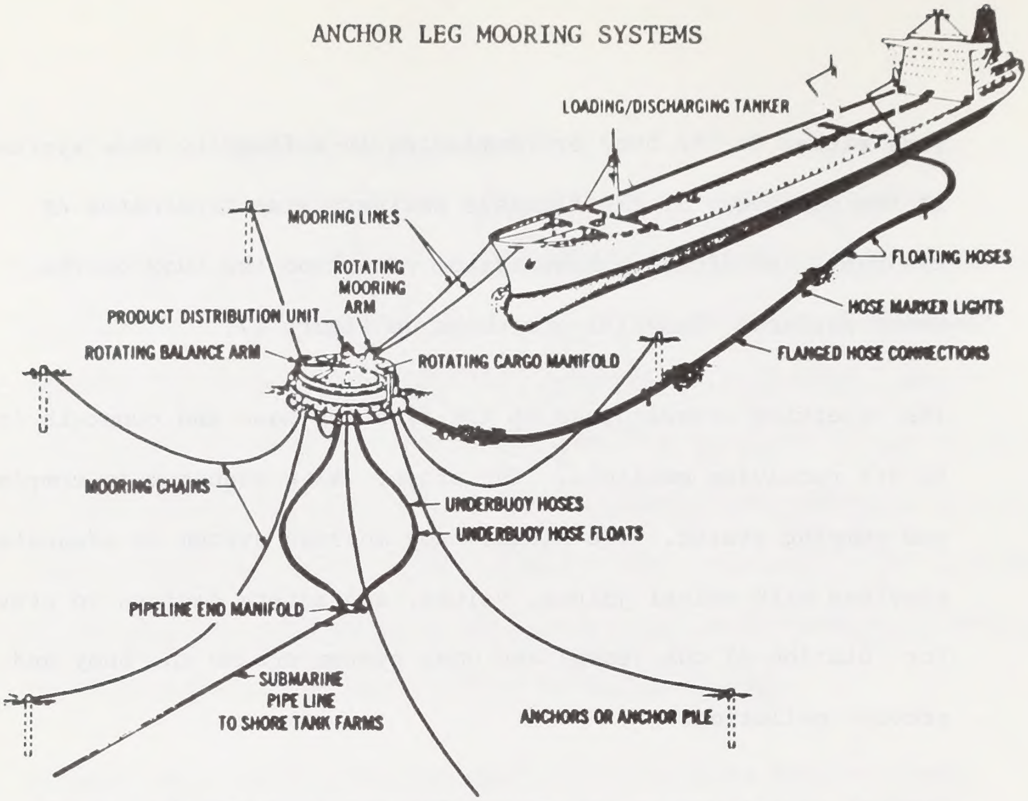
Several types of offshore loading terminals have been designed, some are under construction, and many are in operation throughout the world. Most of the newer systems consist of a single buoy to which the receiving vessel (tanker or barge) is moored. This allows the vessel to swing around the buoy according to wind and current effects. The buoy is securely anchored to the ocean floor using either a single anchor leg system or a catenary anchor leg system (multiple anchor chains). The anchor lines are fixed to structures driven or cemented to the ocean floor to prevent all but small lateral movement of the buoy. The delivery pipeline terminates below the buoy and a flexible delivery line from the pipeline runs either to the buoy or terminates in a floating hose system at the surface. If the flexible delivery line terminates at the buoy, the floating hose system runs from the buoy on the water surface. Examples are shown on figure 17.

The receiving vessel picks up the floating hose and connects it to its receiving manifold. The proper valve sequence is completed and pumping starts. The single buoy mooring system is adequately provided with swivel joints, valves, and safety devices to provide for rotation of the vessel and hose system around the buoy and to prevent pollution.

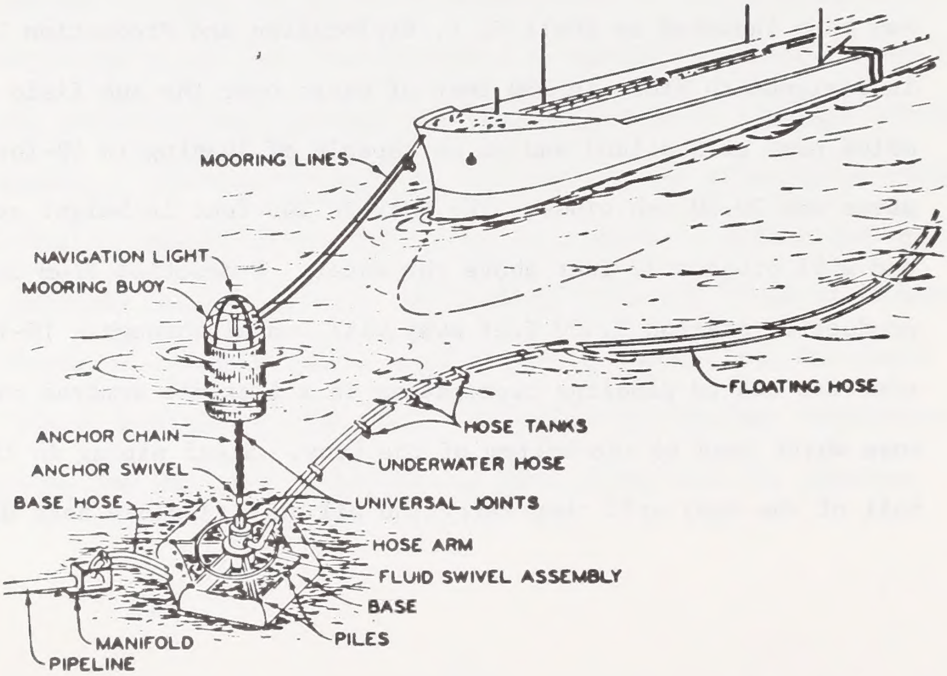
Several variations on the principles involved have been made. The newest system, especially designed for North Sea exposed locations, has been launched by Shell U. K. Exploration and Production Ltd. It is designed to float in 280 feet of water over the Auk field 186 miles east of Scotland and to be capable of loading in 12-foot waves and 20-30 mph winds. The buoy is 243 feet in height overall and will project 72 feet above the water. Production from the production station 6,500 feet away will travel through a 10-inch concrete coated pipeline terminating in a flexible armored rubber hose which lead to the bottom of the buoy. Steel piping in the hull of the buoy will then carry the oil to a flexible hose delivery

FIGURE 17.

ANCHOR LEG MOORING SYSTEMS



A - Schematic of catenary anchor leg mooring (CALM) system.



B - Schematic of single anchor leg mooring (SALM) system.

Source: Seadock, Inc. (Also presented at the Sixth Annual Offshore Technology Conference, Houston, Texas, May 6 - 8, 1974) system. The surface portion of the buoy consists of a massive fender structure. The deck of the fender structure contains the delivery hose reels and handling system. The buoy contains a turntable system to which the vessel moors allowing it to remain in the same relative position to the buoy regardless of wind and wave direction. The buoy is topped by a helicopter landing deck and suspended from this deck are living quarters for maintenance men.

APPENDIX 9

History of Drilling and Offshore Oil and Gas Operations

1. Drilling for Hydrocarbons

In spite of the many exploration methods in use today, their utility is limited to exposing the possible presence of a hydrocarbon accumulation. The only method of definitely ascertaining the presence of producible hydrocarbons is by drilling.

Drilling may be accomplished by two methods. The older of the two is the cable tool method which involved the use of percussion tools that were repeatedly lifted and dropped on the end of a rope or steel cable to penetrate the sub-surface strata. This method is still in use in some areas for special purposes, and still is widely used in the water-well industry. However, the general method of drilling in the oil industry, particularly offshore, is the rotary method.

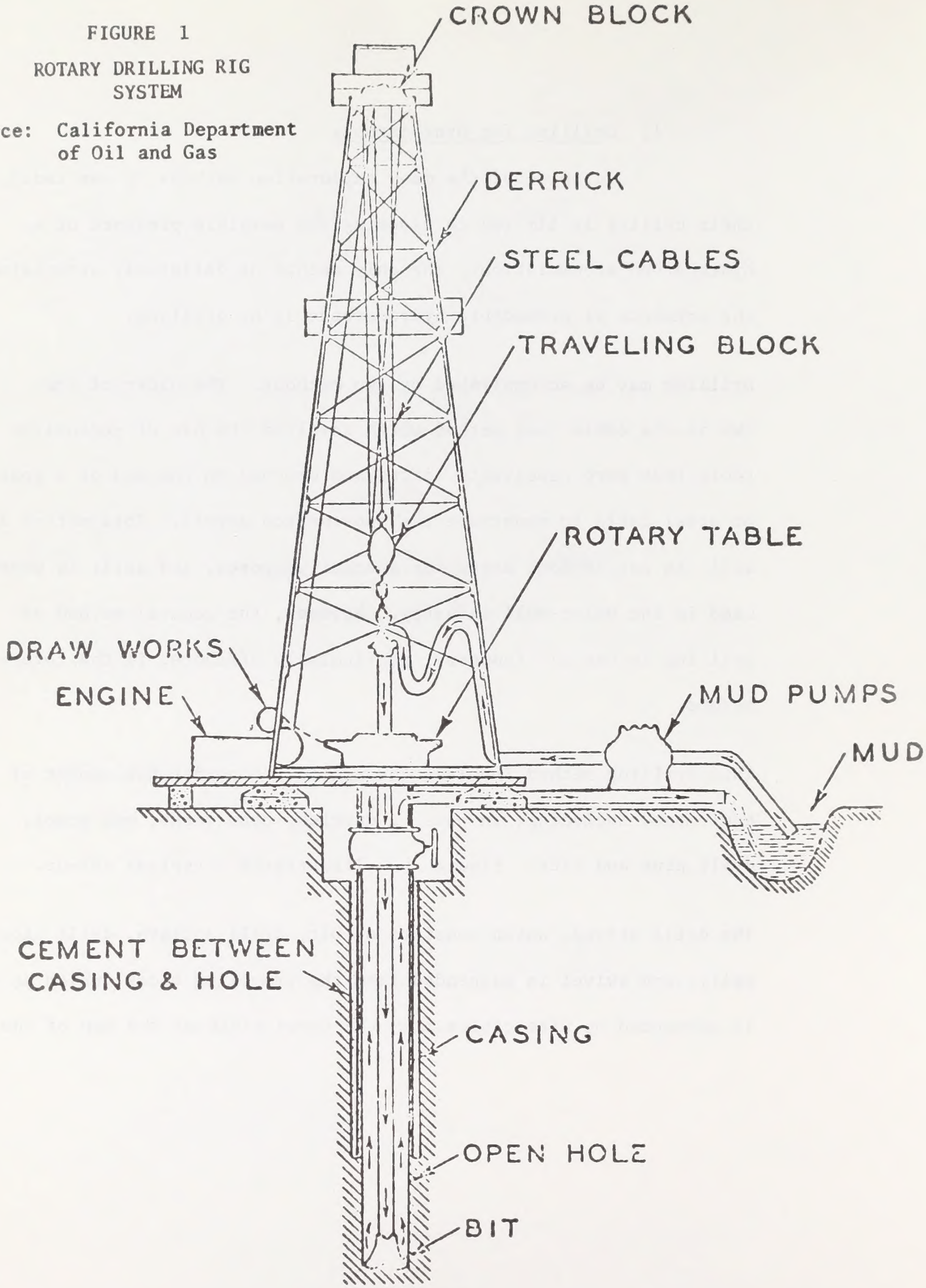
This drilling method involves the use of a considerable amount of equipment, including, in part, a derrick, draw works, mud pumps, drill pipe and bits. Figure 1 illustrates a typical set-up.

The drill string, which consists of bit, drill collars, drill pipe, kelly, and swivel is suspended from the traveling block, which in turn is suspended by wire cables from the crown block at the top of the

FIGURE 1

ROTARY DRILLING RIG
SYSTEM

Source: California Department
of Oil and Gas



derrick. The cables are connected to the draw works which serves to raise and lower the drill string. The drill string passes through the rotary table on the derrick floor and the kelly, a multi-angular joint (generally square in cross-section) fits in a matching opening in the table to give rotational movement to the drill string. The rotary table is also powered from the draw works.

As drilling is continued, additional joints of drill pipe are added to the drill string below the kelly joint. The entire drill string is hollow and attached to the swivel above the kelly joint is a flexible mud line. This line is connected to the mud pump which draws the drilling fluid, or mud, from the mudsump. The drilling fluid is especially composed to obtain the particular chemical and physical properties required for each well.

a. The Drilling Fluid

The drilling fluid, or drilling mud, is pumped down the drill string and out through the bit. The fluid, jetting through the bit, picks up the drill cuttings and carries them up the hole through the annulus to the surface. The mud return line, from the well surface, carries the fluid to the shale shaker. This is a vibrating screen that retains the cuttings, but allows the fluid to pass through and be returned to the mud sump. A generalized mud system is shown in figure 2.

The drilling fluid is one of the most important components of the rotary drilling system. In addition to carrying the drill cuttings to the surface, it performs other necessary functions. The weight of the column of fluid in the hole is controlled by additivies to support the sides of the uncased hole and prevents caving. The weight also prevents the entry of fluid from any porous formation penetrated.

b. Directional Drilling

Holes may be drilled vertically, as is the usual case, but in cases where the drilling equipment cannot be placed directly over the desired bottom hole location, the well can be deflected both vertically and horizontally to reach the exact location desired. Many wells, particularly in California, have been drilled from shore locations at the ocean's edge to extend out under the sea. Some of these wells have been deflected as much as 70 degrees from the vertical.

c. Casing

When drilling commences, the first string of casing, or large diameter pipe, is set from the surface to a shallow depth. Depending on the area, this depth may be as little as 30 feet to

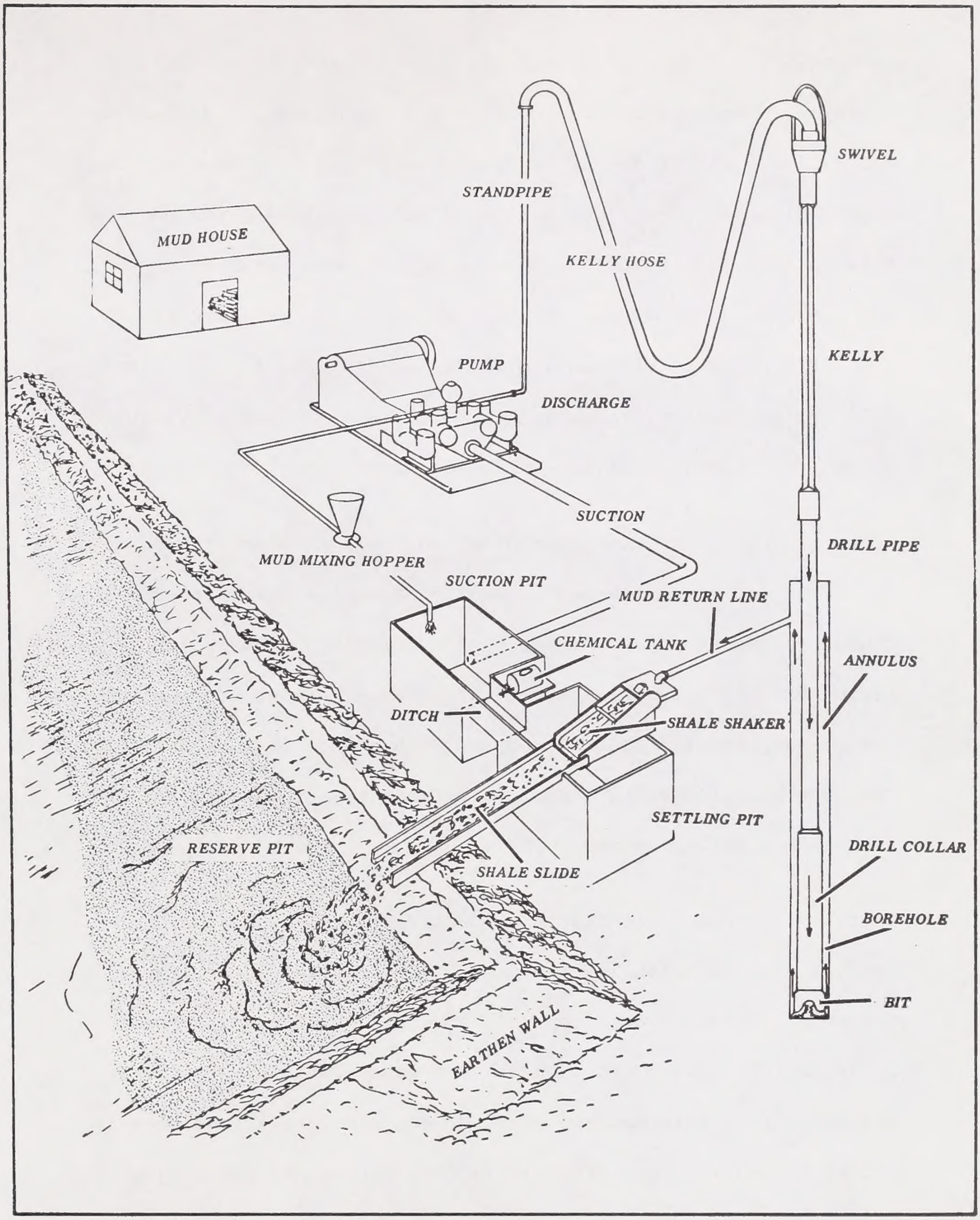


FIGURE 2

ROTARY RIG FLUID CIRCULATION AND MUD TREATING SYSTEM

Source: Petroleum Extension Service, The University of Texas at Austin, and others, 1973, p. 31.

more than 500 feet (on the Pacific OCS, 100 feet is the nominal minimum). The hole to accommodate this casing may be drilled by the drilling rig or it may be driven or jetted down to a solid, compitent base. The first string, commonly called the conductor pipe is then set on bottom and is cemented from total depth to the surface. The purpose of this casing string is primarily to provide a means of circulating the drilling fluid in subsequent drilling operations, returning it to the mud pit and providing a base for the blow-out prevention equipment.

After cementing the conductor pipe, the well is then drilled to a depth, depending on the area, usually below the lowest fresh water zones, but above any potentially productive hydrocarbon zones. A second string of casing, called the surface casing, is then run to bottom and cemented from the bottom with the cement extending through the open hole,through the annulus between the conductor pipe and the surface string to the surface.

Drilling is then continued to the desired total depth and the final string of casing is cemented. The last casing string is called the production string. In some areas there may be only three casing strings run. In other areas additional strings of casing, called intermediate strings, are run for various reasons. All of the casing run after the surface string may extend from the bottom to the surface, or some may extend from bottom to a point within the next higher string. In the event they do not extend to the surface they are called liners. Casing run after the surface string may also be cemented from bottom to surface or to some point within the next higher string. In the case of liners the cement extends from the bottom to the top of the liner. Usually, at least one of the casing strings run after the surface casing extends to the surface and is cemented to the surface. Most regulatory agencies have regulations concerning the number of casing strings required, setting depth, and cementing procedures.

The number of casing strings run depends on many factors, the type of formations encountered, pressures in the formation, depth of well, etc. As the number of casing strings is increased the strength and security of the well is increased, but each successive string must be smaller in diameter than the preceding string so a carefully considered casing program must be developed prior to drilling. Figure 3 shows a typical arrangement of casing strings.

d. Blowout Prevention Equipment

This equipment is set on the conductor pipe and all subsequent drilling operations are conducted through the BOP's,

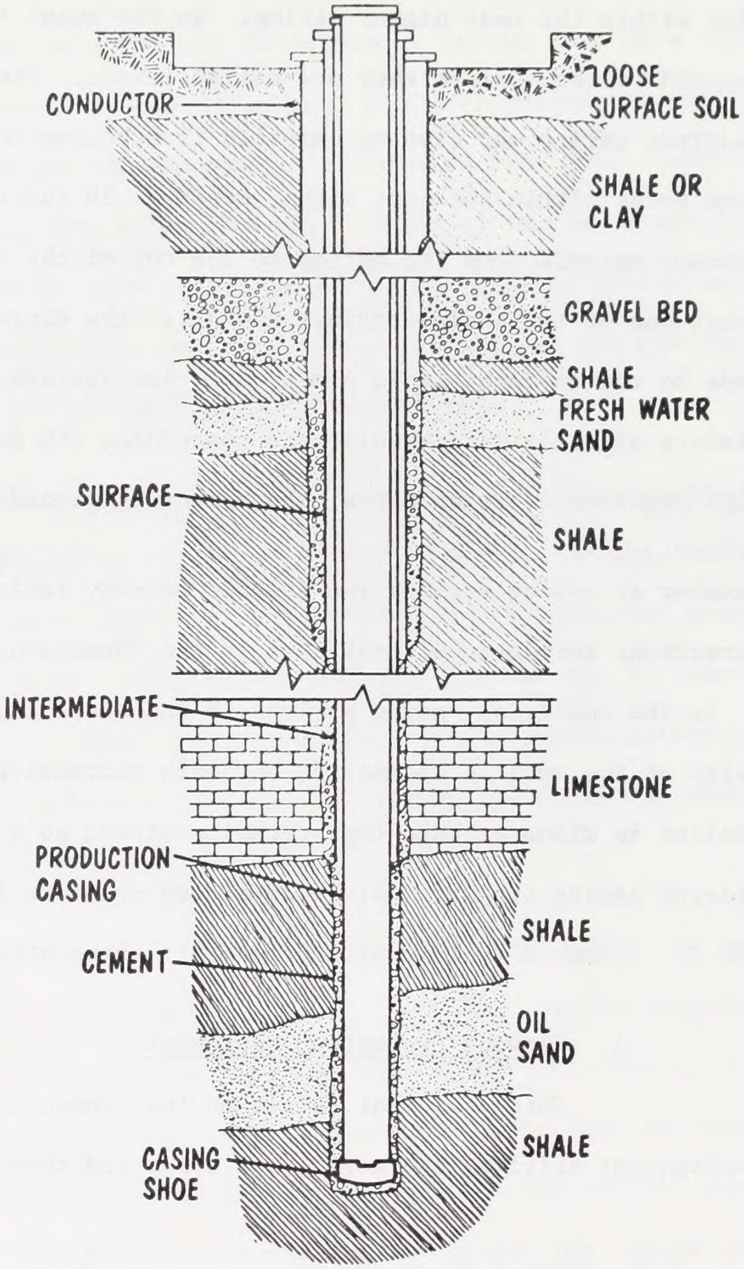


FIGURE 3

CASING STRINGS AND PIPE USED IN AN OIL WELL

Source: Petroleum Extension Service, The University of Texas at Austin, and others, 1973, p. 48.

or blowout preventers. They are a series of valves, usually operated remotely and hydraulically or pneumatically controlled. In case the primary well control system, the drilling fluid, fails to prevent a hazardous situation from developing, this equipment can be actuated to shut-in the well.

There are basically two types of BOP's. One is an inflatable bag type that will expand around any object in the hole and shut off the annular space. The second is a ram type that when actuated will shut off the entire hole. A pipe ram preventer is one that will seal around a particular size pipe in the hole. Another of these types is called a shear blind ram which can shear through drill pipe in the hole and seal in the well. Figure 4 shows simplified versions of blowout preventer types and figure 5 shows a typical BOP arrangement for land drilling.

e. Well Completion Methods

When a well encounters productive horizons, it must be completed to make it possible to recover the hydrocarbons. Since there are many types of reservoirs with widely varying characteristics, there are many types of completion procedures.

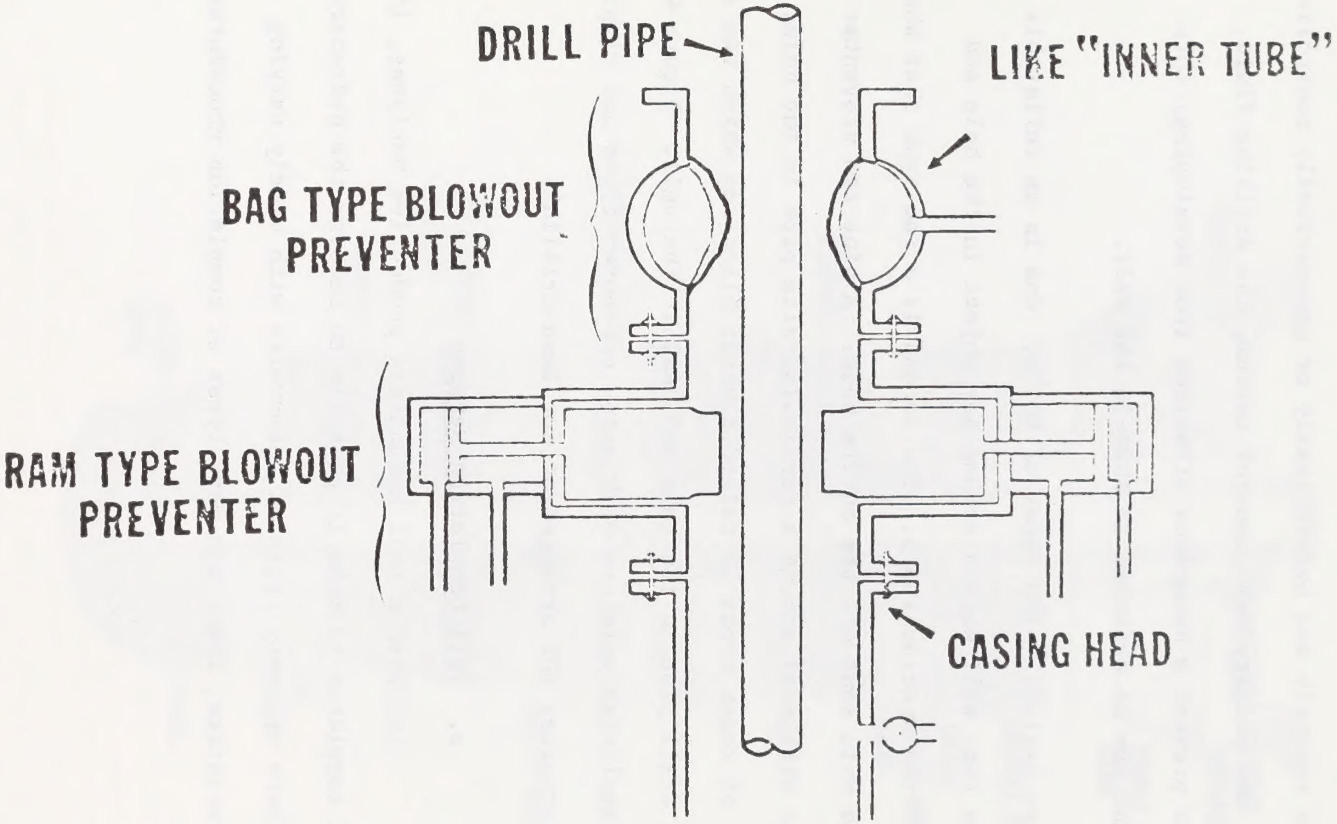
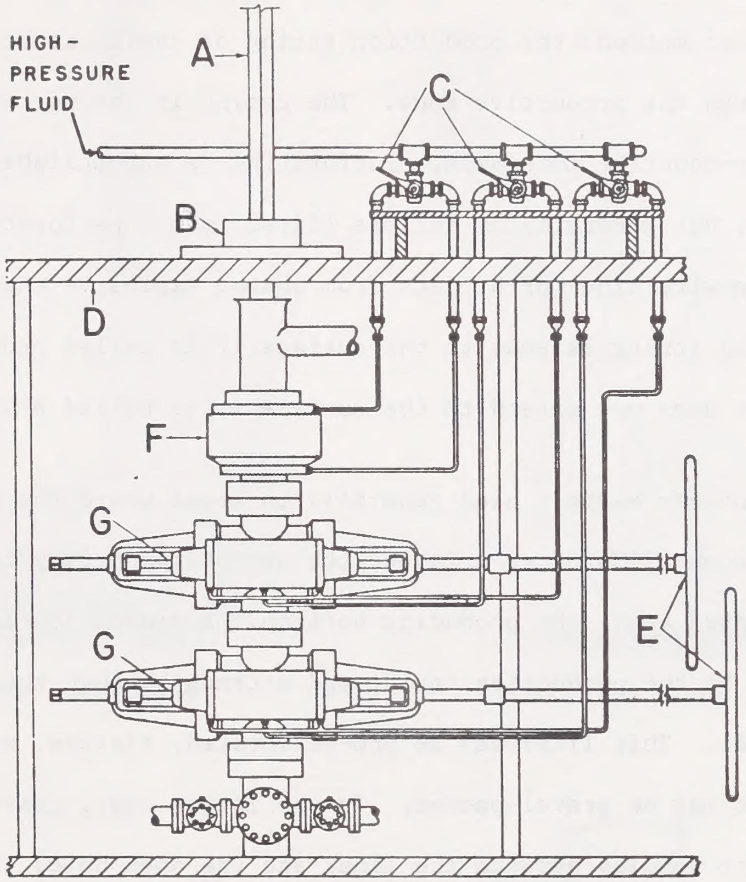


FIGURE 4

BAG TYPE AND RAM TYPE BLOWOUT PREVENTERS

FIGURE 5
TYPICAL BLOWOUT PREVENTER STACK ARRANGEMENT



Source: Petroleum Extension Service, The University of Texas at Austin, and others, 1957, p. 45.

KEY

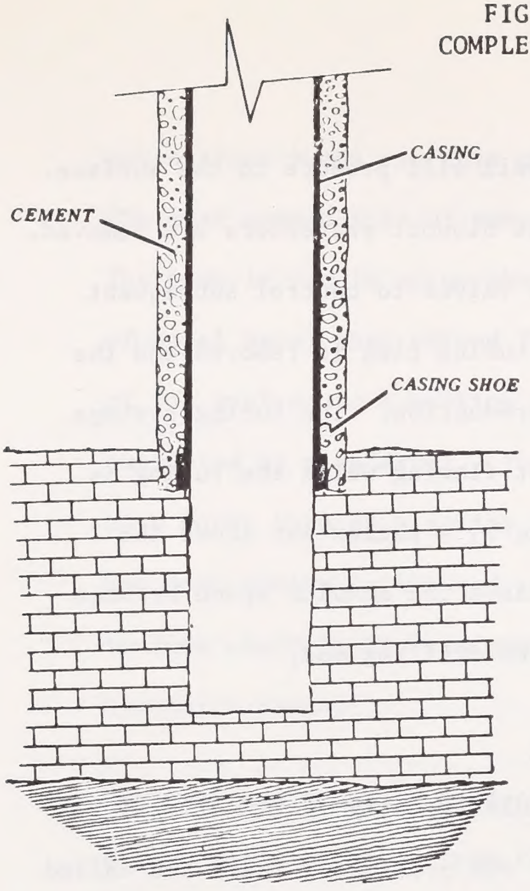
A = Kelly
B = Rotary table
C = Hydraulic controls on derrick floor
D = Derrick floor
E = Manually operated controls on side of substructure
F = Top preventer, which contains large rubber element capable of sealing around any tool protruding through casing head
G = Pipe rams, which close off hole

In the simplest methods, the production casing is cemented above the productive zone and the well is completed open hole. In another method, the production string of casing is set and cemented through the productive zone. The casing is the perforated opposite the productive intervals. Perforating is accomplished in various ways, but generally by bullets (fired from a perforating gun run in on wire line) or by jets from shaped explosive charges. If this casing string extends to the surface it is called production casing, if it does not extend to the surface it is called a blank liner.

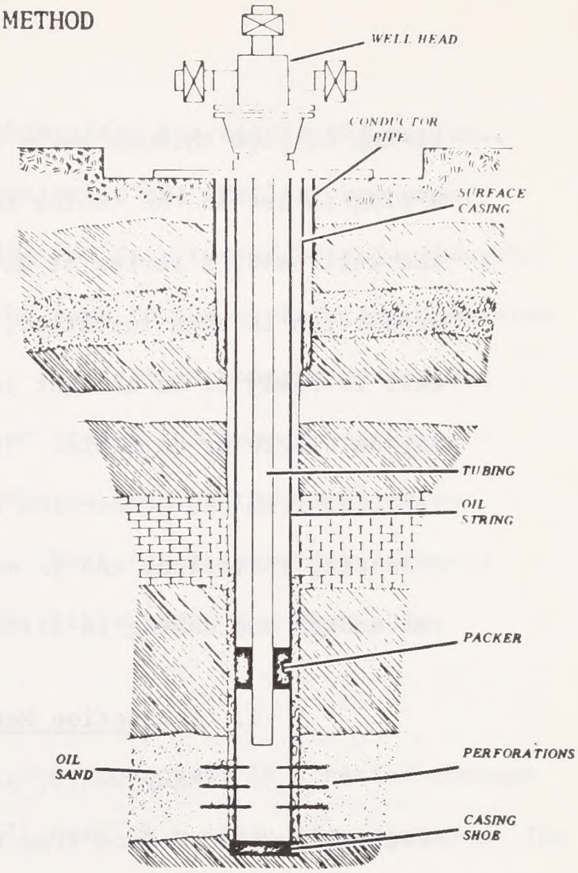
In another method, used generally in areas where the producing zone is unconsolidated or friable, the production string is set and cemented above the producing horizon. A production liner is then hung in the production casing and extends through the productive interval. This liner may be pre-perforated, slotted, wire-wrapped, or it may be gravel-packed. In the latter case, gravel is placed in the annulus between the liner and the open hole. This type of completion, with many variations, is common in many areas of California. Figure 6 shows these completion methods.

When the well is capable of production, the tubing is run and hung from the tubing head below the blow preventers. The tubing is the

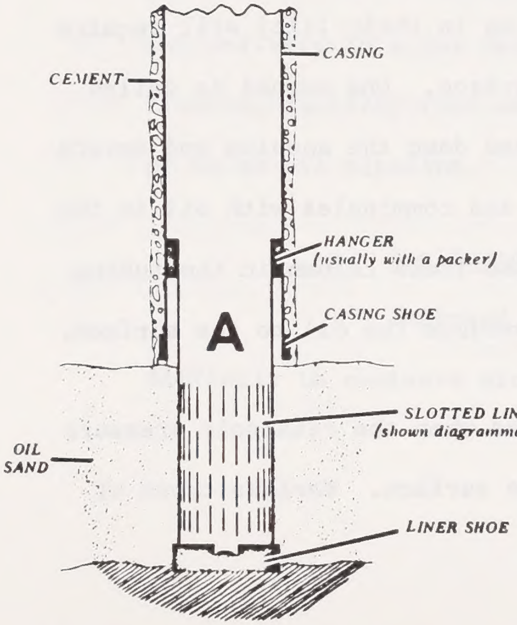
FIGURE 6
COMPLETION METHOD



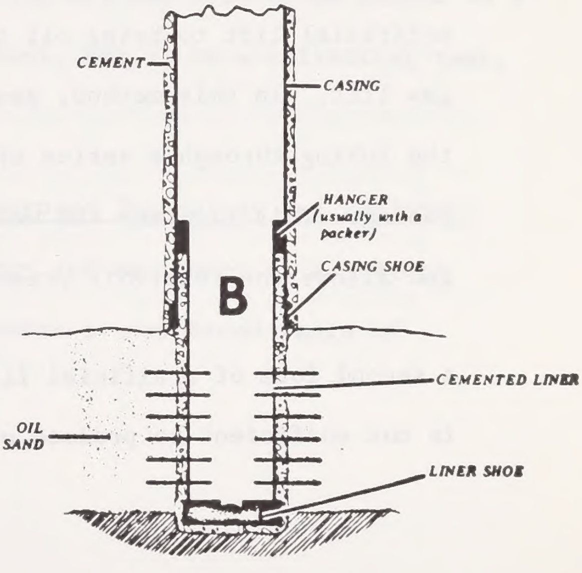
Open-hole completion.



Perforated casing completion.


CASING
CEMENT
HANGER (usually with a packer)
CASING SHOE
A
SLOTTED LINER (shown diagrammatically)
OIL SAND
LINER SHOE

Slotted liner completion.



Perforated liner completion.

Source: Petroleum Extension Service, The University
of Texas at Austin, and others, 1973, p. 64-65.

string of pipe through which the well will produce to the surface. A plug is set in the tubing and the blowout preventers are removed. The well head, a series of surface valves to control subsequent production is then installed, the tubing plug is removed and the well is ready to be brought into production. The tubing strings may be single or multiple. In most flowing wells the tubing is isolated from the production casing by a packer set above the producing formation, and in many cases the annulur space between the tubing and casing is filled with drilling mud.

f. Production Methods

Many wells, particularly early in the life of a reservoir, will produce from their own pressure. These are called natural flow wells.

Other wells (and most wells at some time in their life) will require artificial lift to bring oil to the surface. One method is called gas lift. In this method, gas is pumped down the annulus and enters the tubing through a series of valves and commingles with oil in the tubing. This lightens the weight of the fluid column in the tubing and allows the reservoir pressure to produce the oil to the surface.

A second form of artificial lift is used when the reservoir pressure is not sufficient to produce oil to the surface. Various types of sub-surface pumps run into the tubing lift the oil to the surface. The most common type of pumping system is the familiar rod pump. The pump is run in or on the tubing and is actuated by rods (lengths of metal bars) that extend from the pump to the surface and connected at the surface to a walking beam. The beam is mounted on a pivot supported by a pedestal. The other end of the beam is actuated by a motor through a series of linkages to give the familiar up and down motion to the rod string. More recent pump developments include electrically operated submersible pumps and down-hole hydraulic pumps.

Whatever the means of production, the production is directed through a flow line connected from the well head to a production station. The first stage in the production station is generally a separator where gas and oil are separated. The gas then flows to a gas pipe line for delivery to a gas facility. The oil may flow or be pumped to a treating facility (for water removal, etc.), to a collecting tank, or to an oil pipeline.

g. Application of Improved Technology and Equipment

Improved technology and equipment is a subject difficult to evaluate since it covers a very broad range of possibilities. Also it is a field that is constantly changing and, in addition, any improvement derived from improved technology or equipment would depend to a large extent on the reservoir characteristics.

Some methods of productive improvement that can be considered are:

(1) Drilling Fluid and Completion Fluid Design

The quality and composition of the fluid used in drilling through the productive zone and the fluid used during the completion phase of the well are very important in determining the productive capability of the well as compared to the potential productive capability of the well.

Some reservoir rocks may contain quantities of clay that swell on contact with water and reduce the permeability, or clays may wash out reducing the competency of the reservoir rock, or water in the interstitial spaces can itself reduce permeability to oil, or emulsions can be formed in the reservoir to reduce permeability, or the filter cake formed on the face of the well bore can partially block production--there are many possibilities, each dependent on reservoir characteristics and the fluids introduced.

(2) Clean-up Fluid Design

Several types of fluids have been designed to repair damage around the well bore after completion and after extended production. The type depends on the character of damage and the intent in their use is to restore reservoir permeability to its original state. Mud-acids are used to remove particles left after completion or deposited after a period of production. Various detergent type fluids are used to break down emulsions and clean up the formation around the well bore. Various petroleum-based products such as diesel fuel are used for the same purpose. Aluminum hydroxide may be used to reduce clay swelling that results in reduced permeability. Many other chemicals are used for other purposes, such as scale buildup on liners.

(3) Liner Design and Sand Control Techniques

Many shallower reservoirs in California are composed of sandstones in various degrees of compentency. The production of sand with the reservoir fluid leads to a great many problems: the well itself can plug up and therefore require frequent cleanouts in order to be able to produce; sand traveling with the production fluid can cut out production equipment downstream from the well; and, most seriously, sand caving in the vicinity of the well bore can reduce permeability in the peripheral zone, the most critical area, to the point where the well may not be able to produce. Normally, therefore, the ideal completion technique is to leave the area around the well bore in an essentially undisturbed state during the productive life of the well.

Several liner designs have been used in an ateempt to attain this ideal. Slotted liners, where the slot size is determined by the sand grain size and distribution have been developed. Other liner designs, such as wire-wrapped and gravel pre-packed have also been designed to solve this problem. One of the more successful solutions has been to run the liner and then gravel-pack the annular space between the liner and the well bore.

Several other sand control methods have also been devised for sand control. Generally they involve injecting a sand consolidation fluid in the area around the well bore. Various types of plastic compounds that are injected as a fluid and later set up as a honeycombed solid are used for this purpose. Other methods involve injecting various chemicals for the same purpose.

(4) Pumping Methods and Pump Improvement

The familiar rod pumps actuated by a walking beam are still used on land and in some offshore areas, but they are not too practical for offshore application, especially in deeper water where platform space is at a premium. Platform construction is too expensive to allow for space taken up by the large pumping units.

When pumping is required on offshore wells, and for special applications on land, the usual choice is between a down-hole submersible pump and a hydraulic pump. The former is an electrically operated rotary pump characterized by high volume delivery while the latter is a hydraulically operated piston pump.

The original submersible pumps were run on tubing, but models have been developed to be run on wire line. Besides high volume capability the only surface requirement is an electrical source. These pumps are especially suitable in wells with high water cuts, such as fields with water injection, where a large volume of fluid with a relatively low percentage of oil can be economically lifted. A primary problem is scale control, due to produced water, and this problem can be solved by proper chemical treatment.

There are several variations of the hydraulic pump, but basically it is a piston-type pump actuated by a power fluid pumped down the tubing or through a power line run in conjunction with the tubing and are retrieved by reversing the flow direction. The latter quality is a big advantage in offshore situations since no extra equipment is required to service the pump. A surface pump and power source is required for the power fluid, but the space required is relatively small. Originally one problem was that their efficiency was greatly diminished by even low quantities of gas produced with the oil, but this problem has been largely solved by improved design.

In some hydraulic pump designs the power fluid is returned to the surface commingled with the production fluid. This offers an additional advantage where production is heavy and viscous and a lighter oil is available for power fluid. Commingling decreases viscosity and specific gravity of the produced fluid and increases pump efficiency.

(5) Wax and Scale Control

Accumulations of wax or scale can seriously limit a well's productivity. Waxy deposits are generally a result of a decreasing temperature up the hole and deposits can created a problem in the tubing or further along in the production flow pattern. Both mechanical and chemical methods are used to remove these deposits.

Scale is generally deposited from chemicals included in the water produced with the oil. It can limit production through liner slots severely as well as create high losses in pump efficiency. Treatment is usually chemical and depends on the characteristics of the scale deposit. The chemical is usually injected down the casing, either continuously, or in batches, but occasionally elaborate cleanout measures are required.

(6) Emulsion Control

Many reservoirs, with the proper combination of characteristics between oil and water, temperature, etc., produce an emulsion that is extremely difficult to break down. However, this is largely a question of economics, since, given the proper equipment (heat and/or electrolytic sources) and chemical treating facilites, most emulsions can be broken down. If treatment were required on an offshore platform the problem of space could be the most important factor.

These are only some examples of methods that may be used to increase production from wells through improved technology and equipment; there are undoubtedly many other methods such as improving completion techniques in shutting off gas and/or water, improving cementation methods, improving wire-line techniques and tools, improving clean-out methods. etc. In general, none of these methods, nor those discussed above, will improve the potential, ultimate production from a reservoir. They may help to reach this potential and they may also help to improve the rate of production. They may simply improve the economics of production and therefore increase the ultimate production from a reservoir that may economically be reached. In many cases improved technology will result in obtaining part of the potential that would otherwise not be recoverable.

2. Background and History of Offshore Technology

This section is not necessarily essential to the main purpose of this Environmental Impact Statement and does not relate solely to the Pacific OCS, but it may serve to clarify some of the subjects discussed elsewhere in the Statement.

Offshore development was originally conducted in much the same manner as onshore development. Because of the differences in operational requirements environmental quality considerations, particularly as the search for oil progressed to deeper and deeper water and the distance from shore increased, various new methods of accomplishing the basic requirements for oil field development under these conditions were devised.

Offshore technology, as related to the driling and production of oil wells, has progressed a great deal since some of the earliest offshore wells were completed off southern California and in the relatively calm and shallow waters of the Caspian Sea and Lake Maracaibo (Venezuela). Offshore production was initiated in Summerland, California, in 1896, when a well was completed under the Santa Barbara Channel from a pier extending from the beach. However, probably the most significant major advances in technology, as related to the present state of the art, began about 35 years ago when oil drilling began in the Gulf of Mexico.

a. Early Offshore Wells

The first offshore wells were drilled from wooden piers extending from shore. In the early 1920's, single well platforms, usually close to shore and in shallow waters, were constructed on wooden piling driven to resistance in the sea bottom. All the drilling equipment, materials and supplies were contained on the platforms.

Production, or collecting, stations were built on separate, but similar, platforms and the platforms were connected by walkways also supported on piling. Flow lines were led along the walkways to the production station. Since most operations were close to shore another walkway would be built connecting the installation to shore and carrying the pipeline to shore.

These operations were common in Lake Maracaibo and in the southern California area such operations were conducted in the 1920's and even earlier at Summerland, Elwood and Rincon in the Santa Barbara Channel area.

The first advance came in the 1920's when drilling tenders began to be used. Platforms were constructed as before, a derrick would be erected on the platform and the drilling equipment: drawworks, rotary, egines, etc. would be installed. A tender barge would then be moored to the platform. The barge would carry mud and supplies, the mixing and sump tanks, mud pumps and required pipe. In this manner the platform size and cost was reduced. Figure 7 shows a modern tender-assisted fixed offshore drilling platform.

All the operations required to drill, complete, and produce the wells were the same as for an onshore well. The only difference was that the conductor casing and subsequent casing strings extended above the sea floor to a point below the drilling platform. The

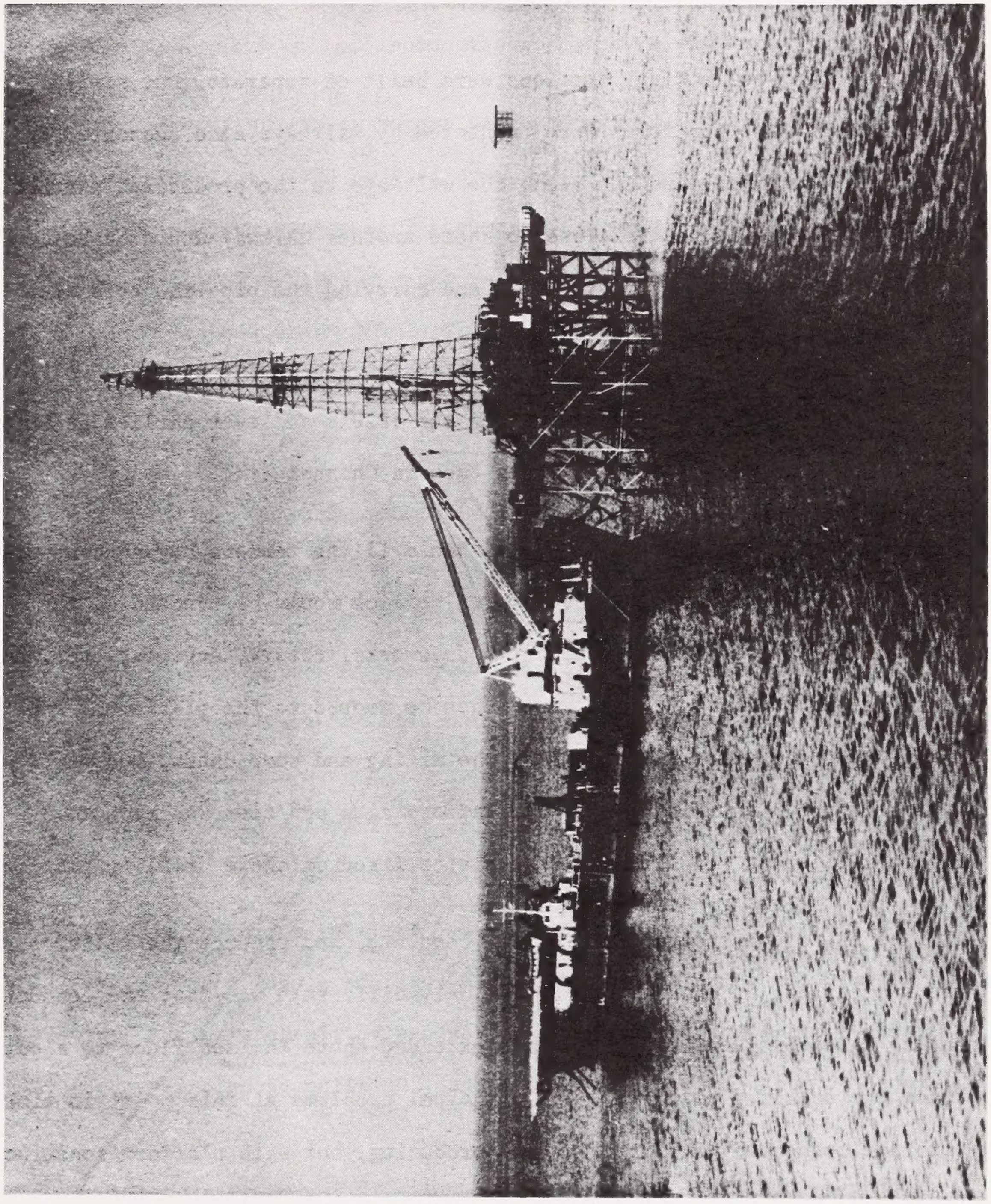


FIGURE 7 TENDER ASSISTED FIXED DRILLING PLATFORM

principal problems at this point were not with drilling and producing, but with platform construction.

As the search for oil progressed to deeper water the first change in procedure was that pipelines were laid on the sea floor and connected to the platforms by risers. This change was due to the increasing cost of driving piles as the water depth increased. For the same reason, multiple well platforms where several wells were directionally drilled from a common platform began to be used.

During this period, improvements were made in many phases of the technology. Pile construction methods were improved as were the driving techniques. The first concrete piling was used in Lake Maracaibo and in 1940 the first application of steel piling was used in the Gulf Coast area. Pipe laying procedures were improved and pipes were coated, both for protection and for the necessity to reduce their buoyancy as water depth and pipe sizes increased. In 1934 the first underwater pipeline burying machine was used in Galveston Bay. Cathodic protection measures began to be used to protect pipe from corrosion. To reduce costs, drilling equipment was split into modular units so that the units could be placed on the platforms in single lifts, without the expensive rig-up time and derrick construction time previously required. Drilling techniques also improved, but were still primarily developed on the same lines as those used on land. In 1933 a notable advance in offshore technology was made with the first offshore geophysical surveys carried on by boat in Galveston Bay.

b. Mobile Drilling Platforms

As the platform costs increased it was recognized that exploratory drilling costs could be substantially decreased if the drilling platform were movable. In the case of a dry hole, the cost of a permanent platform is essentially unrecoverable and in fact represents an additional expense for removal.

The first movable platforms designed for offshore work were barges designed to be moved to the location and sunk in place to rest on the bottom and provide a stable drilling platform. These were first used in the shallow waters off Louisiana in 1933 and some are still in use. Naturally their utility is severely limited by the water depth.

In the early 1950's jack-up drilling platforms were developed where the drilling equipment, derrick or mast and draw works were mounted on a floating platform. The platform was equipped with "legs", three or more, which were connected to "jacks", by means of which the legs could be raised or lowered. On arrival at the location, the platform was moored in position and the legs lowered to the sea floor. Then, as the legs took the weight, the platform was raised the required distance above the water surface. A tender barge was then moored to the jack-up and drilling proceeded as from a permanent platform.

If the well was successful, a permanent well platform was constructed at the site after the jack-up departed. This platform could be constructed much less expensively than a permanent drilling platform since it was not designed to carry the load of the drilling equipment. In case additional work, requiring drilling equipment, was necessary at a later date, the jack-up rig could be moved in over the small production platform.

Although jack-up rigs similar to those described above are still in use, later models have been designed and are in use. Some have much larger platforms with all drilling equipment and supplies, including mud and pipe, carried aboard. Some of these rigs are also self-propelled. Most of these larger rigs have crews' quarters and facilities, as well as heliports. Figure 8 shows a transition type jack-up, constructed in 1957 for use in 180 feet of water.

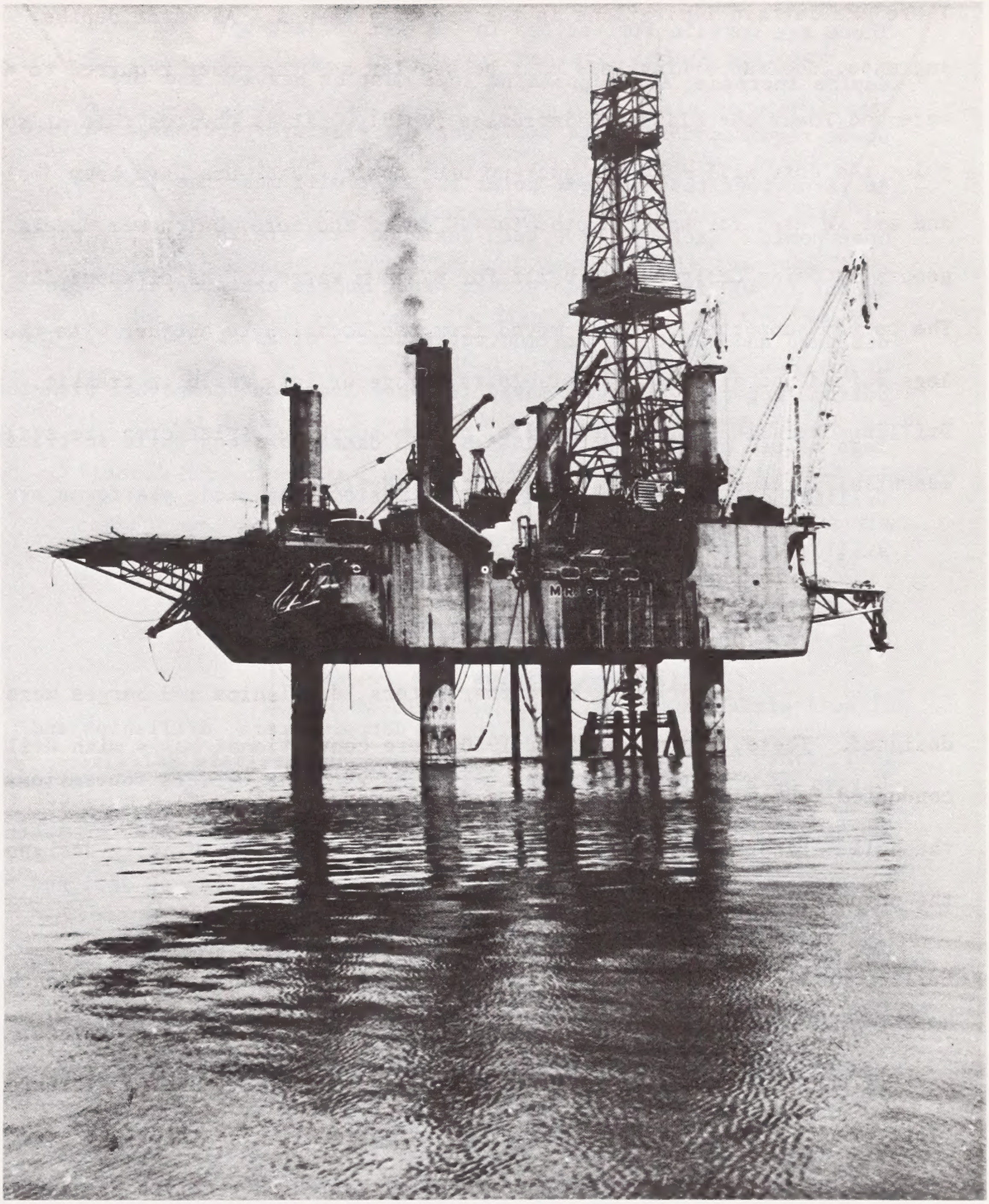


FIGURE 8 FOUR LEG JACK-UP MOBILE DRILLING PLATFORM

There are certain limitations in the use of jack-ups. As water depths increase, the supporting legs must be heavier and the power required to elevate and lower the platforms increases rapidly. It is obvious that at some point the cost will make the jack-up uneconomic. Jack-ups have been designed, and are in use, for water depths to 400 feet, and more, but newer models are generally being designed and built for maximum water depths of about 350 feet. The bottom supported rigs are moved from one location to another with the legs raised and are most vulnerable to damage or loss while in transit. Drilling operations from the mobile, bottom supported, platforms are still essentially the same as for fixed platform drilling.

c. Floating Drilling Platforms

(1) Drill Ships

For drilling in deeper waters, drillships and barges were designed. These, beginning about 1950, were conventional hulls with drilling conducted from a platform over the side or stern, or through a well cut through the hull. Later models are designed and built on hulls expressly designed for the purpose.

Earlier drilling was conducted with the vessel moored in place by an anchoring system with the tension on the anchor lines keeping the vessel in place. In most of the later models position keeping is aided by the use of "thrusters" (jets or propellers acting in different directions). The thrusters are actuated by a signal sent from a computer system which receives its input from either, or both, of two systems: (i) the angle of displacement from vertical of a line attached from the vessel to the bottom; or (ii) a sonar signal measuring the position of the vessel relative to a sonar beacon fixed in place on the ocean floor. More recently, such vessels have been designed with computer controlled, dynamic, positioning equipment designed to keep the vessel in place without the use of anchor systems.

(2) Semi-Subermsibles

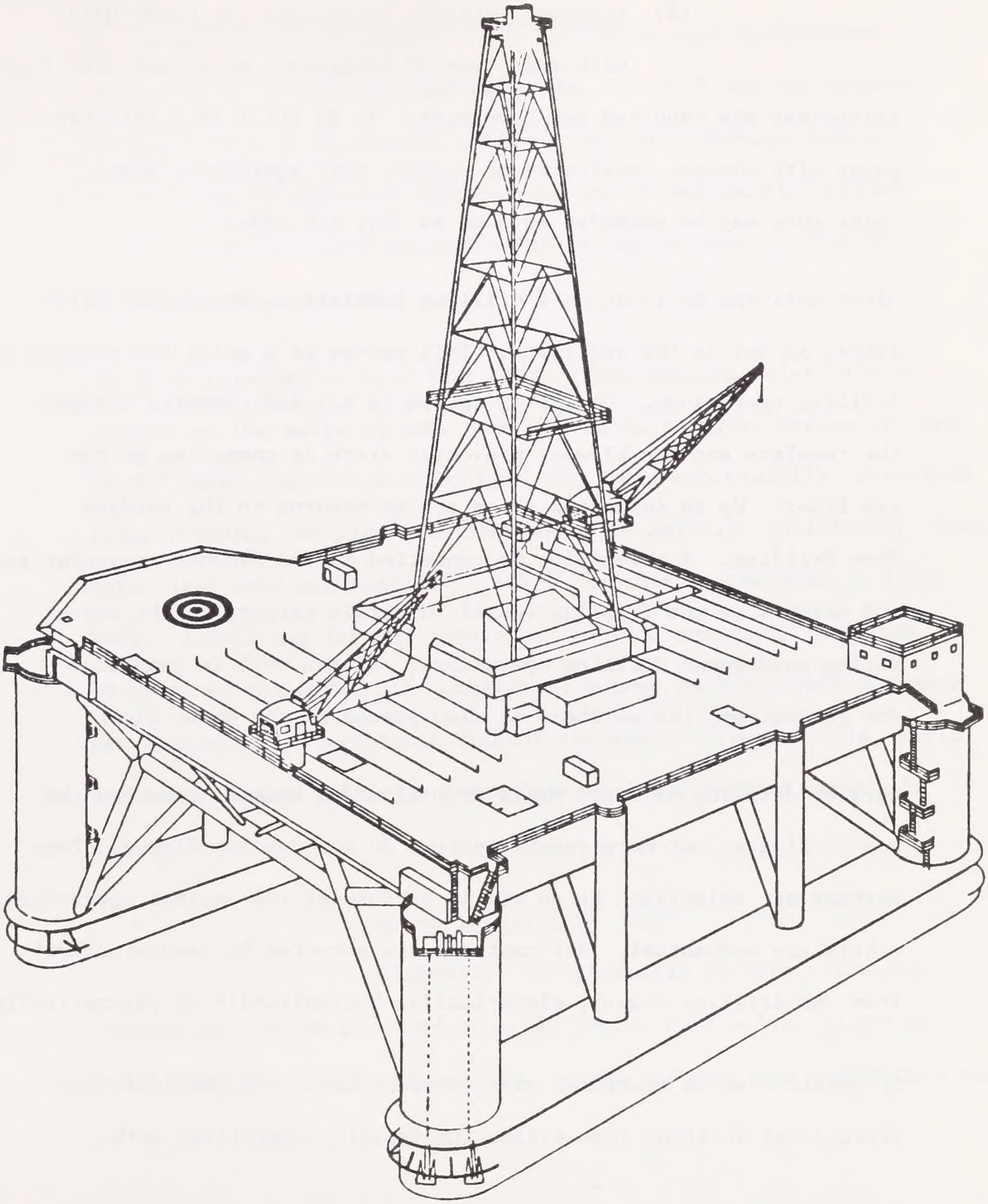
By 1963 the first semi-submersible floating drilling platform was completed. These differ from conventional drilling ships in that the drilling platform is supported on legs extending from buoyant pontoons or chambers. When moving from one location to another, the buoyancy chambers are evacuated to give maximum buoyancy and the vessel is supported by them. On arrival at location, the chambers are flooded to partial buoyancy sufficient to support the platform the required elevation above the ocean surface. The advantage of this design is that the center of gravity is lowered and the buoyancy chambers are below the surface of the water. This minimizes the response to wave forces and stabilizes the motion of the drill string and working floor. Figure 9 shows one version of a semi-submersible, built in 1972 for use in water depths of 600 feet and with a drilling depth capability of 25,000 feet.

The first semi-submersibles were designed to be moved from location to location using towing vessels, but later designs are self-propelled. These vessels are held in place at the drilling site using the same systems as the drill ships and the drilling techniques are the same for each type of vessel.

There are differences of opinion as to which type of floating vessel is the better. Each has its advantages, but it is generally agreed that the semi-submersible is the more stable platform and it is preferred for use in areas where storms and rough seas are prevalent. The primary advantage of the drillship is its mobility and it may be preferred where exploratory locations are far apart, particularly if the area is not in a severe weather zone. The drillship is also generally somewhat less expensive than the semi-submersible.

FIGURE 9

SEMI-SUBMERSIBLE DRILLING PLATFORM



Source: Western Oil and Gas Association, Outline of Anticipated OCS Platforms

(3) Floating Drilling Techniques for Cased Holes

With this type of drilling a whole new drilling technology was required and developed. It is still in a formative phase with changes developing so rapidly that statements about techniques may be outmoded as soon as they are made.

After arriving on location a drilling template equipped with guidelines, is set on the sea floor. This serves as a guide for subsequent drilling operations. Conductor casing is set and cemented through the template and the blowout preventor stack is connected at the sea floor. Up to this time there are no returns to the surface from drilling. A riser pipe is connected to the blowout preventer stack and extends to the drilling vessel to permit returns to the vessel during subsequent drilling operations. If the well is completed for production, the wellhead is also placed on the ocean floor.

Earlier drilling of cased wells from floating vessels required the use of divers, but more recent systems do not require divers. Some systems use television as an aid in performing the various operations, others are mechanical. All controls are actuated by remote control from the drilling vessel, electrically, hydraulically or pneumatically.

It should also be mentioned that adequate tools are available for directional drilling from a floating vessel, controlling both wellbore angle and direction. The technique used is the same as that used on land or platform wells. Five of the exploratory wells drilled in the Federal area of the Santa Barbara Channel by floating vessels were plugged back and directionally drilled to new objectives with maximum wellbore angles ranging from 24 to 38 degrees.

It is of interest to note that cores (from uncased holes with no returns to the surface) have been recovered in water depths of over 20,000 feet. Such core holes have also been successfully re-entered after tripping the pipe with the vessel dynamically positioned. Cased holes have been successfully drilled in water depths down to 1,400 feet. A well drilled and completed (left in condition to be re-entered) by the Shell Oil Company off Borneo in 1,170 feet of water was successfully re-entered without the use of divers. Also, Shell has successfully drilled a cased hole in 2,150 feet of water off Gabon.

(4) Subsea Completions

Originally, and generally to date, floating vessels were primarily used to drill exploratory wells, with the wells considered to be expendable. After testing, the exploratory wells were abandoned and development wells were drilled from fixed platforms. Drilling from a fixed platform has a number of advantages, the primary one being that wells can be drilled as from shore locations with all valves and connections at the surface. However, there is a practical depth limit for fixed platforms. Costs increase geometrically with depth and it is generally conceded that presently a maximum depth limit of about 1,200 feet approaches this limit.

Exploratory sites, while understandably not always located at the most desirable spots for maximum reservoir drainage, are expensive to drill and saving the wells for future use in field development would represent a significant economic advantage. For this reason many exploratory wells are now only temporarily abandoned with provisions left for the well to be re-entered at a later date for a subsea completion. Or wells may be completed after testing as a subsea completion.

Several different sorts of subsea completion systems have been developed. The simplest is the so-called "wet" completion, where the wellhead valves and connections are located on the ocean floor. Valves can be manipulated and connections can be made by divers or by remote mechanical control from the surface. Some systems use television to perform these functions, others use purely mechanical methods. These systems have been extensively tested, usually in fairly shallow water, to date, and their practically has been proven.

Shell Oil Company has successfully completed several wells in the Molino gas field in the Santa Barbara Channel at depths of up to 275 feet. Phillips Oil Company has completed wells at depths of 230 feet in their Ekofish field in the North Sea. These completions were made with the use of divers. Many other similar completions have been made in other parts of the world including the Gulf Coast and the Persian Gulf.

The earlier subsea completion systems required the use of a surface vessel and, in some cases, divers, to perform any down hole maintenance. Now, systems have been devised to use pump down tools in conjunction with wire-line methods to perform many functions. With these tools, the only time a surface vessel would be required would be to perform major down hole work such as a workover.

Since diver capabilities are limited by water depth, other procedures, involving protective capsules or hemispheres over the wellheads and other production equipment are being developed by Shell, Exxon, and other companies. Those procedures involve the use of an entry lock on the protective capsule and a second personnel vehicle that can be lowered to the capsule, attached to the entry lock and permit personnel to work at atmospheric pressure. Extensive surface tests of these systems have been conducted to demonstrate their feasibility. In September, 1972, Shell installed such a subsea completion on a well in the Gulf of Mexico in 375 feet of water. In September of 1973 the well was successfully re-entered for routine maintenance. Shortly it is expected that field tests will be initiated for multi-well manifold systems and complete production systems.

Diver operated facilities have a depth limitation due to diver capability. Routine dives are presently made to about 600 feet with a potential capability of about 1,200 feet. Systems using surface remote control of operations and the capsule system have a present probable technical limitation of about 2,000 feet.

(5) Production Facilities

Generally, production facilities for these wells are either onshore or on nearby platforms. However, a diver operated complete production facility including separators and transfer pumps is in operation in the Arabian Gulf in 70 feet of water. The facility is operated by the British Petroleum Company and the Compagnie Francaise de Petrole.

As mentioned above, field tests are expected shortly for protective capsule systems over multi-well manifolds and complete production facilities that will permit work under water at atmospheric pressure.

d. Present Trends in Offshore Production

In the earlier days of development drilling, the wells were drilled from a drilling platform. The well's production was then delivered to a nearby production platform that contained the required production facilities such as separators, treaters, gauging facilities, temporary holding tanks, transfer pumps, etc. However, with increasing water depths and rising costs of platform construction, many platforms are now used for both drilling and for production facilities. Most platforms have more than one deck each of which may be used for various purposes. For example, one deck may be used for drilling. Wellheads are generally located below the drilling deck and in the case of a platform from which many wells are directionally drilled there may be more than one level containing the wellheads. This permits a staggered wellhead arrangement and thus increases the number of wells permitted in the horizontal space occupied by the platform. Production facilities, crews accommodations, etc. may be located on one or more additional levels.

These platforms and, in general, most deepwater platforms are pre-fabricated, from steel, on shore and floated to the location and sunk in place. Most of the platforms are fixed to the sea floor by piling, but some are fixed by gravity. More recently, structures of concrete have been developed.

Storage facilities for offshore wells have in the past generally been located onshore. But with increasing distances from shore, especially in the North Sea, offshore storage facilities have been constructed or are in construction. The Ekofisk field in the North Sea has a 900,000 barrel concrete storage facility on the ocean floor in 230 feet of water. This particular installation is a combination drilling, production and storage facility with a 216-mile long, 34-inch oil line coated and buried from 3 to 10 feet below the ocean floor at a maximum depth of 312 feet. A second pipeline for gas is also connected to this platform. It is 36 inches in diameter, 249 miles long, and is also buried. Each line has two intermediate booster platforms. Several other similar platforms are either in construction or planned in the North Sea. One is presently under construction for the Brent field in 460 feet of water.

At several locations temporary and permanent storage facilities have been used consisting of a tanker or barges moored in a location to receive production for transshipment to conventional tankers.

Pipelines have been successfully laid and connected in 524 feet of water in the Gulf of Gaeta and a line is contracted for to be laid from Algeria to Sicily and thence to Italy in water depths up to 1,500 feet. A technical capability exists to lay lines in water depths of up to at least 4,000 feet at the present time.

REFERENCES

Drilling Vessels

Collier, C. L. and D. S. Hammet, Dynamic stationed drill ship SEDCO 445: SEDCO, Inc., Paper No. OTC 2034.*

Hammet, D. S., 1974, Drilling in ultradeep water without anchors or guidelines: SEDCO, Inc. in Petroleum Engineer, May, 1974.

Kennedy, J. L., 1973, New rigs must handle coming Gulf of Mexico boom: The Oil and Gas Journal, May 6, 1973.

Williams, D. W. and D. S. Hammett, Shelf-propelled all weather semisubmersible drill rig: SEDCO, Inc., Paper No. OTC 2033.*

World Oil Staff, 1974, New BOP actuator is designed for 10,000-foot waters: World Oil, May, 1974.

Historical Background and Present Status

American Petroleum Institute, Primer of oil production.

Berryhill, H. L., Jr., The worldwide search for petroleum offshore - a status report for the quarter century, 1947-1972: U.S. Geological Survey Circular 694.

Blakley, W. B., 1974, Where offshore production stands today: The Oil and Gas Journal, May 6, 1974.

Department of Conservation, Division of Oil and Gas, State of California, Non-living resources, oil and gas resources in the onshore coastal zone.

U. S. Department of the Interior, United States petroleum through 1980.

University of Texas, at Austin, A primer of oil well drilling: Petroleum Extension Service.

Vetco Offshore, Inc., Why and how of undersea drilling.

Western Oil and Gas Association (WOGA), Outline of anticipated oil field operations, Outer Continental Shelf offshore southern California (OCS Sale Number 37).

* Presented at the Sixth Annual Offshore Technology Conference held in Houston, Texas, May 6 - 8, 1974.

Pipelines

American National Standard Institute, American National Standard liquid petroleum transportation piping system: ANSI B34.4-197 434.15, in-press.

Brownfield, W. G. (Williams Brothers Engineering Company), 1973, Using geology to lay subsea pipelines: Offshore, September, 1973.

Ewing, R. C., 1974, New jet barge buries pipe in 350-foot depth: The Oil and Gas Journal, April 1, 1974.

Gordon, H. W., and W. R. Rochelle, 1974, Subsea pipelaying limits deepen: Brown and Root, Inc. in The Oil and Gas Journal, June 7, 1974.

Hemphill, D. P., E. A. Milz, and R. R. Luke, Repair of offshore pipelines in water depths to 3,000 feet: Shell Development Company Paper No. OTC 1939.*

Johnson, P. K., 1971, A reel-type pipelaying barge: Civ. Eng. - ASCE, October, 1971.

Lagers, G. H. G. (IHC Gusto B.V.), and C. R. Bell (Viking Jersey Equipment, Ltd.), The third generation lay barge, Paper No. OTC 1935.*

Milz, E. A., and D. E. Broussard, Technical capabilities in offshore pipeline systems to maximize safety, Shell Development Company paper presented at 1972 Offshore Technical Conference, Dallas, Texas.

Offshore, Staff, 1973, Submersible cutter dredge has working depth capability of 200 feet with 300 more on tap: Offshore, March, 1973.

Oil and Gas Journal, 1974, Offshore lines spawn new techniques: The Oil and Gas Journal, May 6, 1974.

_________________, 1974, Work starts on North Sea's deepest pipeline: The Oil and Gas Journal, June 24, 1974.

Oil and Gas Journal, Staff, 1974, Laying costs jump as lines go deep: The Oil and Gas Journal, January 7, 1974.

_________________, 1974, Ekofisk to Emden gas line international affair: The Oil and Gas Journal, June 3, 1974.

* Presented at the Sixth Annual Offshore Technology Conference held in Houston, Texas, May 6 to 8, 1974.

Silvestri, A. (Saipem S.p.A.), 1974, North Sea difficulties produce new deep-laying pipeline methods: The Oil and Gas Journal, May 20, 1974.

Platforms and Structures

Brannon, H. R., T. D. Loftin, and J. H. Whitfield, Deepwater platform design: ESSO Production Research Company, Paper No. OTC 2120.

Gerwick, B. C., Jr., Preparation of foundations for concrete caisson sea structures: University of California, Paper No. OTC 1946.*

Guy, A. L., 1974, Platform for 850 feet of water nears the construction phase, EXXON Company in the Oil and Gas Journal, May 20, 1974.

Harrison, D. S., and J. D. Duggan, 1974, New concept speeds offshore development: Offshore Consultants, London, in Petroleum Engineer, May, 1974.

McDonald, R. D., The design and field testing of the "Triton" tension-leg platform and its future application for petroleum production and processing in deep water: International Marine Development, Ltd., Paper No. OTC 2104.*

Minorsky, V. U. (George Sharp, Inc.), and H. Sharman (Hersent Deep Sea Structures, Ltd.), Self-erecting gravity-type steel production platform for 350 to 500-foot water depths in North Sea, Paper No. OTC 1950.*

Payne, D., 1974, Gravity structures should be placed in proper perspective: Marine Concrete Structures, Inc. in Offshore, May, 1974.

Pliskin, L., Deep and very deep oil storage tanks: Sea Tank Company, Paper No. OTC 1945.*

Oil and Gas Journal Staff, 1974, Tallest production platform set for North Sea: The Oil and Gas Journal, May 27, 1974.

Petroleum Engineer Staff, 1974, Phillips group begins permanent production: Petroleum Engineer, May, 1974.

____________________, 1974, Sea tests scheduled for buoyant platform: Petroleum Engineer, June, 1974, Paper No. OTC 2098.*

* Presented at the Sixth Annual Offshore Technology Conference held in Houston, Texas, May 6 to 8, 1974.

Subsea Production and Completions

Adams, J. R. (Seal Petroleum Corporation), and J. F. Morneul and R. W. Cook (Perry Oceanographics), New offshore recovery advancements for deep water completions: Paper presented at Offshore Technical Conference, April 24 to May 2, 1973, Houston, Texas.

Bleakley, W. B., 1973, New subsea deep production technique unveiled: Oil and Gas Journal, October 29, 1973.

Chatas, A. T., and E. M. Richardson (Seal Petroleum Corporation), Subsea manifold system: Paper No. OTC 1967.*

Fahlman, G. H., Safety characteristics of Lockheed's subsea production system: Lockheed Petroleum Services, Ltd., Paper No. OTC 2098.*

Goodfellow, R. and A. Webb (The British Petroleum Company), and J. Harbonn (Compagnie Francaise des Petroles, S.A.), Subsea experience gained at Zakum: Paper No. OTC 1942.

Mercier, B. M., F. Higler, G. Vine, and E. Darnborough, Handling the seal intermediate system for subsea wellhead completions from the support vessel Terebel: Subsea Equipment Associates, Ltd., Paper No. OTC 1941.

Webb, A. D., 1973, Zakum subsea production is electric powered: The Oil and Gas Journal, December 31, 1973.

Wickizer, C. L., The Shell-Lockheed subsea completion and production system: Shell Oil Company, Paper presented at the American Petroleum Institute Meeting, Denver, Colorado, April 9 to 11, 1973.

Tanker Mooring

Bax, J. D., 1974, First SPAR storage-loading buoy project posed complex design, construction problems: IHC Gusto, Netherlands, The Oil and Gas Journal, June 10, 1974.

Patton, K. L. and D. A. Johnson, SEADOCK: A deepwater petroleum unloading facility: SEADOCK, Inc.

* Presented at the Sixth Annual Offshore Technology Conference held in Houston, Texas, May 6 to 8, 1974.

Peterson, C. K. and C. A. Prince, Rapid transfer of large volumes of crude oil from storage to tanker: Dubai Petroleum Company, Paper No. OTC 1930.*

Van Heijst, W. J., A new flexible pipe system replaces submarine hoses in SBM: Single Buoy Moorings, Inc., Paper No. OTC 1934.*

* Presented at the Sixth Annual Offshore Technology Conference held in Houston, Texas, May 6 to 8, 1974.

APPENDIX 10
DESCRIPTION OF THE ENVIRONMENT
AND
REFERENCES

APPENDIX 10

A. Geology

A. Geology

1. Stratigraphy and General Geology

The following sections describe the stratigraphy and general geology of the mainland and the offshore islands. They are based on unpublished USGS information. Figures A-1, A-2 and A-3 depict stratigraphic columns for the western Santa Ynez Mountains, Ventura River area and the Los Angeles Basin and offshore area, respectively. Geology of the Borderland is illustrated in Graphic 11.

a. Basement Rocks

Basement rocks on the mainland coast and on the islands consist of several distinct types, all of which are believed to be pre-Late Cretaceous in age. In the Santa Ynez Mountains, north of the Borderland, fault slivers of basement rock along the Santa Ynez fault zone are composed of severely deformed graywacke, shale, and chert bodies that are intruded by serpentine and greenstone (Vedder et al., 1969). On Santa Cruz Island, chloritic schist intruded by dioritic rocks, in part, of Late Jurassic age, forms a fault-bounded belt that extends from the west coast through the center of the island (Weaver et al., 1969). On the mainland to the east, in the eastern Santa Monica Mountains, a slightly metamorphosed shale-and-graywacke unit, some of which is Jurassic in age, is intruded by quartz diorite of early Late Cretaceous age. In the northern Peninsular

Ranges, granitic rocks of early Late Cretaceous age intrude both volcanic rocks of Late Jurassic (?) to Early Cretaceous (?) and the underlying argillite and graywacke (Yerkes et al., 1965). Distinctive low-grade metamorphic rocks containing a mineral assemblage unlike that of schistose basement rocks in the eastern Transverse Ranges and Peninsular Ranges are exposed in the Palos Verdes Hills and on Santa Catalina Island (Woodford, 1924). The areal distribution of these various basement rocks and the location of their boundaries beneath the Borderland is uncertain, but it seems likely that low-grade metamorphic rocks related to those on Santa Catalina Island underlie most of the region.

Depths to basement rocks in the Ventura Basin are as much as 15,200 m (50,000 ft.) (Curran et al., 1971), more than 9,150 m (30,000 ft.) in the Los Angeles Basin (Yerkes et al., 1965), and at least 4,570 m (15,000 ft.) subsea in the San Nicholas Basin (Parker, 1971).

b. Upper Cretaceous Rocks

Unconformably overlying the basement are thick sequences of Upper Cretaceous age sedimentary rocks. On the mainland coast, thick successions of Upper Cretaceous sedimentary rocks are exposed in the Santa Ynez Mountains and Santa Monica Mountains, but their areal extent is relatively small. In the northwestern Santa Ana

Mountains, strata of the same age form a nearly continuous belt for about 64 km (40 miles) and locally are more than 1,520 m (5,000 ft.) thick; south of Oceanside equivalent sequences are much thinner: near Carlsbad, less than 31 m (100 ft.), at La Jolla, about 259 m (850 ft.) and at Point Loma, about 40 m (130 ft.) (Sliter, 1968). The west end of San Miguel Island is the only place in the Channel Islands where there is an exposed section of Upper Cretaceous strata: there the sequence may be as much as 3,050 m (10,000 ft.) thick (Kennett in Redwine, 1952). Correlative strata have been penetrated by wells on Santa Cruz Island, beneath the shelf north of San Miguel Island and beneath the east-central Santa Barbara Channel (Weaver et al., 1969; Vedder et al., 1969). Structure sections compiled by Curran et al., (1971) infer that Cretaceous rocks underlie all parts of the Santa Barbara Channel and may reach thicknesses of as much as 3,660 m (12,000 ft.). Upper Cretaceous strata have not been reported from the islands south of the northern group.

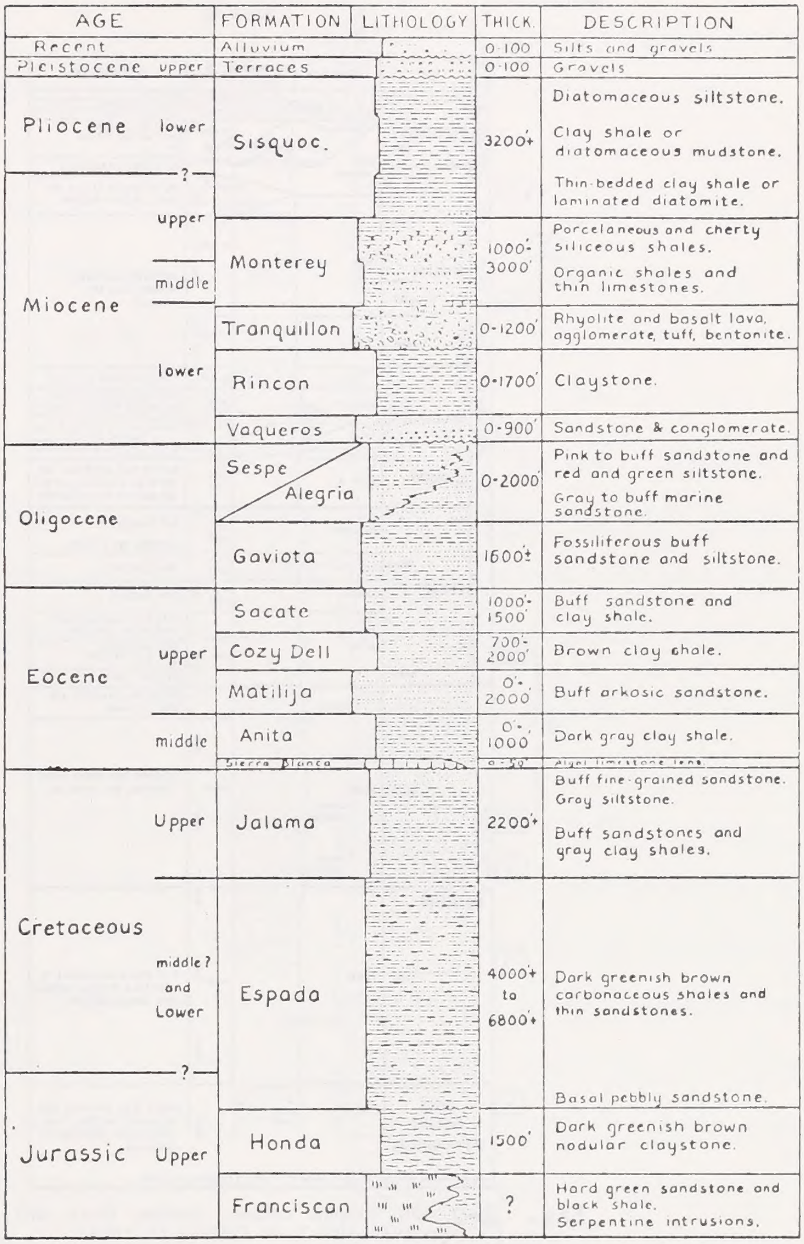
Most of the Upper Cretaceous sequences in Southern California consist of interbedded marine sandstone and mudstone beds that were deposited in a broad range of sedimentary environments. In general, Upper Cretaceous strata in the Santa Ynez Mountains and on San Miguel Island represent turbidite and deep-sea fan deposits, whereas equivalent strata in the Santa Monica Mountains, Santa Ana Mountains and in the San Diego district are chiefly upper slope and shelf deposits.

c. Cenozoic Rocks

i. Paleocene and Eocene

Lower Tertiary marine strata, primarily Eocene in age, are widely distributed in the Sant Ynez Mountains where they consist chiefly of deep-water sediments that may be as much as 6,100 m (20,000 ft.) thick and in the coastal region that extends from the Santa Ana Mountains to San Diego. They also are present beneath the Oxnard Plain and western Santa Monica Mountains and are exposed in the eastern Santa Monica Mountains.

In the northwestern Santa Ana Mountains shallow-marine and nonmarine sandstone and conglomerate beds of Paleocene and Eocene age total about 1,220 m (4,000 ft.) in thickness and an equivalent section near the coast probably is less than 910 m (3,000 ft.) thick (Yerkes et al., 1965). Paleocene rocks are absent in the San Diego district and the Eocene shallow-marine sandstone and shale beds, including nonmarine conglomerate lenses, are about 910 m (3,000 ft.) thick (Kennedy and Moore, 1971). On San Miguel Island, Paleocene sandstone, shale, and conglomerate beds may be as much as 460 m (1,500 ft.) thick and



AGE		FORMATION	LITHOLOGY	THICK.	DESCRIPTION
Recent		Alluvium		0-100	Silts and gravels
Pleistocene	upper	Terraces		0-100	Gravels
Pliocene	lower	Sisquoc.		3200'+	Diatomaceous siltstone. Clay shale or diatomaceous mudstone. Thin-bedded clay shale or laminated diatomite.
Miocene	upper middle	Monterey		1000'-3000'	Porcelaneous and cherty siliceous shales. Organic shales and thin limestones.
	lower	Tranquillon		0-1200'	Rhyolite and basalt lava, agglomerate, tuff, bentonite.
		Rincon		0-1700'	Claystone.
		Vaqueros		0-900'	Sandstone & conglomerate.
Oligocene		Sespe Alegria		0-2000'	Pink to buff sandstone and red and green siltstone. Gray to buff marine sandstone.
		Gaviota		1600'±	Fossiliferous buff sandstone and siltstone.
Eocene	upper	Sacate		1000'-1500'	Buff sandstone and clay shale.
		Cozy Dell		700'-2000'	Brown clay shale.
		Matilija		0'-2000'	Buff arkosic sandstone.
	middle	Anita		0'-1000'	Dark gray clay shale.
		Sierra Blanca		0-50'	Algal limestone lens.
Cretaceous	Upper	Jalama		2200'+	Buff fine-grained sandstone. Gray siltstone. Buff sandstones and gray clay shales.
	middle? and Lower	Espada		4000'+ to 6800'+	Dark greenish brown carbonaceous shales and thin sandstones. Basal pebbly sandstone.
Jurassic	Upper	Honda		1500'	Dark greenish brown nodular claystone.
		Franciscan		?	Hard green sandstone and black shale. Serpentine intrusions.

Fig. A-1 Stratigraphic column, western Santa Ynez Mountains.
(T. W. Dibblee, Jr., 1950)

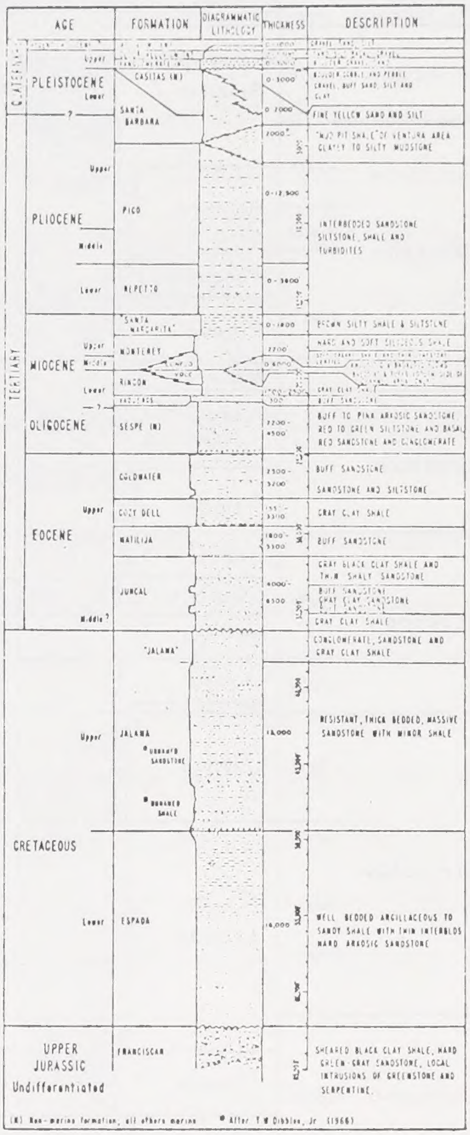

AGE
FORMATION
DIAGRAMMATIC LITHOLOGY
THICKNESS
DESCRIPTION
QUATERNARY
Upper
PLEISTOCENE
Lower
CASITAS (N)
0-3000'
BOULDER COBBLE AND PEBBLE GRAVEL, BUFF SAND, SILT AND CLAY
SANTA BARBARA
0-2000
FINE YELLOW SAND AND SILT
2000'±
"MUD PIT SHALE" OF VENTURA AREA CLAYEY TO SILTY MUDSTONE
TERTIARY
PLIOCENE
Upper
Middle
Lower
PICO
0-12,500
INTERBEDDED SANDSTONE SILTSTONE, SHALE AND TURBIDITES
REPETTO
0-3800
"SANTA MARGARITA"
0-1800
BROWN SILTY SHALE & SILTSTONE
MIOCENE
Upper
Middle
Lower
MONTEREY
2700
HARD AND SOFT SILICEOUS SHALE
0-6000
RINCON
GRAY CLAY SHALE
VAQUEROS
500
BUFF SANDSTONE
OLIGOCENE
SESPE (N)
2200-4500
BUFF TO PINK ARKOSIC SANDSTONE RED TO GREEN SILTSTONE AND BASAL RED SANDSTONE AND CONGLOMERATE
EOCENE
Upper
Middle?
COLDWATER
2300-3200
BUFF SANDSTONE
SANDSTONE AND SILTSTONE
COZY DELL
3300
GRAY CLAY SHALE
MATILIJA
1800-3300
BUFF SANDSTONE
JUNCAL
4000-6500
GRAY BLACK CLAY SHALE AND THIN SHALY SANDSTONE
BUFF SANDSTONE
GRAY CLAY SANDSTONE
GRAY CLAY SHALE
CRETACEOUS
Upper
Lower
"JALAMA"
CONGLOMERATE, SANDSTONE AND GRAY CLAY SHALE
JALAMA
* UNNAMED SANDSTONE
* UNNAMED SHALE
14,000
RESISTANT, THICK BEDDED, MASSIVE SANDSTONE WITH MINOR SHALE
ESPADA
14,000
WELL BEDDED ARGILLACEOUS TO SANDY SHALE WITH THIN INTERBEDS HARD ARKOSIC SANDSTONE
UPPER JURASSIC Undifferentiated
FRANCISCAN
SHEARED BLACK CLAY SHALE, HARD GREEN-GRAY SANDSTONE, LOCAL INTRUSIONS OF GREENSTONE AND SERPENTINE.
(N) Non-marine formation, all others marine
* After T.W. Dibblee, Jr. (1966)

Fig. A-2 -Stratigraphic column, Ventura River area (modified after T. W. Dibblee, Jr., 1966).

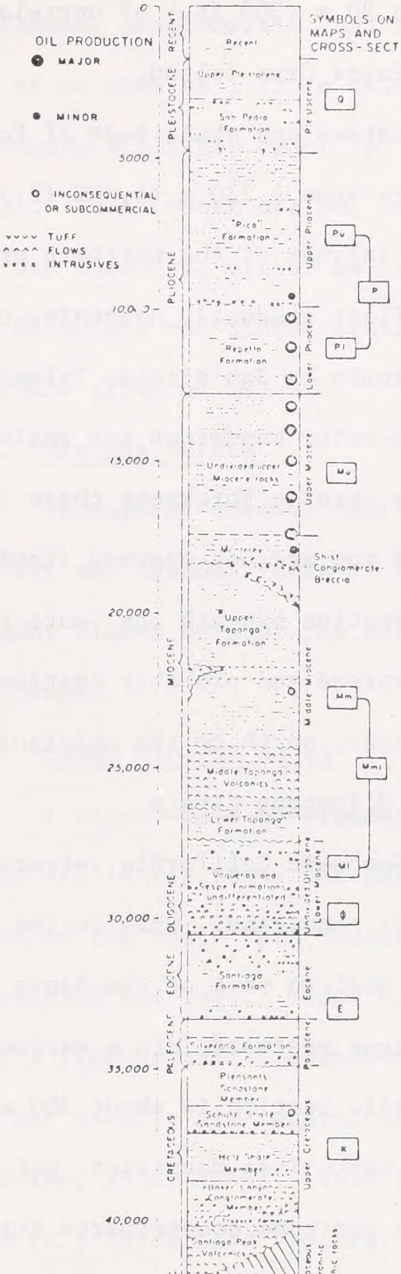


Fig. A-3 –Composite stratigraphic column of Los Angeles basin and offshore area. Thicknesses are essentially maximum and lithology is diagrammatic. Modified and recomposed from Yerkes *et al.* (1965, Pl. 2).

probably represent outer shelf and upper slope conditions of deposition. Less than 90 m (300 ft.) of correlative shallow-water deposits are exposed on Santa Cruz Island.

Marine sandstone and shale beds of Eocene age that have a combined thickness of more than 1,220 m (4,000 ft.) are present on and beneath the three large islands of the northern group (Weaver et al., 1969). These strata reflect gradually deepening conditions through time. Farther to the south on San Nicolas Island, the stratigraphic sequence consists of deep-water sandstone and shale beds of early (?) to Middle Eocene age. The outcrop thickness there is about 1,070 m (3,500 ft.), but the base and top are not exposed (Vedder and Norris, 1963). In the subsurface section beneath the Santa Barbara Channel, Eocene strata are thick, widespread and probably continuous between the outcrops on the Channel Islands, north to the mainland coast (Curran et al., 1971).

ii. Oligocene Strata

In Southern California, strata of Oligocene age are predominantly nonmarine. Only in the western Santa Ynez Mountains and beneath the western part of the Santa Barbara Channel does a red-bed sequence tongue westward into a marine succession. The marine sandstone and shale section is about 300 m (1,000 ft.) thick near the west end of the Santa Ynez Mountains, but its nonmarine sandstone, conglomerate and mudstone counterparts thicken eastward from a wedge edge in the vicinity of Gaviota to as much as 2,440 m (8,000 ft.) a few kilometers east of Ventura (Vedder et al., 1969). About 380 m (1,250 ft.) of equivalent red beds are exposed on Santa Rosa Island and similar rocks are reported from San Miguel Island and from the subsurface section beneath the eastern part of Santa Cruz Island (Weaver et al., 1969). In the Santa Monica Mountains, partly correlative nonmarine sandstone, conglomerate, and mudstone beds have an aggregate thickness of as much as 1,220 m (4,000 ft.), and similar strata in the San Joaquin Hills are about 769 m (2,500 ft.) thick (Yerkes et al., 1965). These rocks are not known to be present southeast of the town of San Clemente, either as outcrop or subsurface occurrences. Neither Oligocene nor older Tertiary rocks have been reported from the southern group of islands.

iii. Miocene Strata

Throughout coastal Southern California and the Borderland, sedimentary and igneous rocks of Miocene age are widely distributed and at many places surpass the early Tertiary rocks in areal extent and thickness.

Lower Miocene Rocks

A narrow belt of transgressive marine sandstone as much as 180 m (600 ft.) thick forms the basal unit of the Miocene along the south flank of the Santa Ynez Mountains where it is disconformable on the underlying red beds. These sandstone beds are conformably overlain by a fine-grained sequence of claystone, mudstone, and siltstone beds that locally are interstratified with thin zones of bentonitic clay (Dibblee, 1950, 1966). This fine-grained unit is as much as 760 m (2,500 ft.) thick near Ventura. A similar succession is exposed on southern Santa Rosa Island 970 ± m (3,200'±) thick and on San Miguel Island 460 ± m (1,500'±) thick; but the basal sandstones are missing on San Miguel (Weaver et al., 1969). Equivalent strata on Santa Cruz Island are about 300 m (1,000 ft.) thick.

In the central and western Santa Monica Mountains, interbedded marine sandstone and siltstone beds about 1068 m (3,500 ft.) thick, which intertongue at the base with nonmarine red beds, thin eastward and lens out. On the east and southeast sides of the Los Angeles Basin, marine strata interfinger with nonmarine beds to the north, but toward the coast they rest gradationally on red beds and are increasingly finer grained as the section thickens in the same direction (Yerkes et al., 1965). Lower Miocene rocks are not known to be present in the area between the San Joaquin Hills and the Mexican border and on the southern group of islands.

Middle Miocene Rocks

Strata of Middle Miocene age in coastal Southern California are characterized by three petrologically distinct facies: an organic siliceous shale, a feldspathic sandstone, and a blueschist breccia and conglomerate. The siliceous shale and related rocks form one of the most widely distributed sedimentary facies along the coast; they are absent only from the Oceanside to San Diego area, Santa Catalina Island, and San Nicolas Island. These shaly strata are known to underlie large parts of the mainland shelf and are exposed on many of the island shelves, banks and ridges on the Borderland (Jennings, 1962; Strand, 1962; Rogers, 1965; Jennings and Strand, 1969). The sandstone unit, which generally is slightly older than the shale unit, is not present in outcrop along the mainland coast between Point Conception and Point Mugu but is exposed north of the Santa Ynez fault and occurs locally beneath the Santa Barbara Channel. The sandstone facies forms a major stratigraphic unit in the Santa Monica Mountains, where it is as much as 1,220 m (4,000 ft.) thick, and along the southeast side of the Los Angeles Basin where it is about 1,020 m (3,500 ft.) thick in outcrop. It probably is absent on the mainland southeast of the San Joaquin Hills. The blueschist breccia and associated conglomerate and sandstone compose a lenticular unit that is discontinuously distributed along the near-coast area from the Santa Monica Mountains to Oceanside (Woodford, 1925; Woodford and Bailey, 1928): it also occurs on Santa Rosa, Santa Cruz, and Anacapa Islands and the adjacent seafloor (Scholl, 1960; Weaver et al., 1969; Yeats, 1970).

Upper Miocene Rocks

Where present along the mainland coast of the Santa Barbara Channel, most of the Upper Miocene section is a diatomaceous mudstone with claystone beds that contain increasing amounts of sandstone higher in the section and eastward in the Ventura Basin. A possibly equivalent section on Santa Rosa Island consists of lenticular beds of sandy siltstone, tuffaceous sandstone, and volcanic agglomerates (Kennett in Redwine, 1952; Weaver et al., 1969). In the Santa Monica Mountains, the Upper Miocene section is about 910 m (2,000 ft.) thick and is composed chiefly of interlayered siltstone, shale, and sandstone; in the Palos Verdes Hills, it is dominantly mudstone that attains a thickness of about 330 m (1,100 ft.). Outcrops near the coast in the southeastern part of the Los Angeles Basin include a mudstone unit similar to that in the Palos Verdes Hills. Farther inland, the subsurface section consists mainly of interlayered sandstone and clayey siltstone units that are as much as 4,087 m (13,400 ft.) thick (Yerkes et al., 1965). Southeast of the town of San Clemente, Upper Miocene strata strike seaward; and a possibly correlative section south of San Diego is only 35 to 50 m (115 to 165 ft.) thick (Artim and Pinckney, 1973). Less than 30 m (100 ft.) of tuffaceous sandstone of possible Late Miocene age overlies volcanic rocks on Santa Catalina Island.

Miocene Volcanic Rocks

Extrusive and intrusive igneous rocks that range in composition from basaltic to rhyolitic form parts of the northern Channel Islands and the western Santa Monica Mountains. Similar rocks, chiefly andesitic, encircle the Los Angeles Basin, both at the surface and at depth (Eaton, 1958), but are not present in the coastal zone southeast of the San Joaquin Hills. The volcanics are Middle Miocene (Yeats, 1968; Turner, 1970). On the southern group of islands, volcanic rocks of Middle Miocene age form most of Santa Barbara (Emery, 1960) and San Clemente Islands (Olmsted, 1958), but constitute less than one third of the area of Santa Catalina Island (Bailey, 1941), and occur only as minor instrusions on San Nicolas Island (Vedder and Norris, 1963) and at Begg Rock. On San Clemente Island, the flow sequence probably is 450 m (1,500 ft.) thick (Olmsted, 1958; Merifield et al., 1971).

iv. Pliocene Rocks

Marine strata of Pliocene age generally are restricted to existing deep depositional basins and their closely adjacent margins. In the vicinity of Ventura, the Pliocene section is 4,575 m (15,000 ft.) or more thick and may be more than 4,270 m (14,000 ft.) thick in the central Los Angeles Basin. In both basins, the strata consist primarily of repetitiously interbedded mudstone and sandstone with minor amounts of conglomerate. In the central basin areas these beds commonly are considered deep-water turbidities. Volcanic ash is present locally in the lower part in the Los Angeles Basin and in the upper part in the Ventura Basin. In the San Diego district, the section is about 300 m (1,000 ft.) thick and is composed of fine to coarse-grained shelf deposits.

v. Pleistocene and Holocene Deposits

Thick accumulations of marine and nonmarine deposits of Pleistocene and Holocene age are preserved at places along the mainland coast and in the interior basins (as much as 1,830 m (6,000 ft.) east of Ventura). On the mainland, these deposits consist of poorly consolidated sediments that range from clayey mudstone to boulder conglomerate and represent such diverse environments as outer shelf through littoral and estuarine, to eolain, flood-plain and stream-bed conditions of deposition. On the islands, these beds are limited chiefly to marine terrace deposits of Late Pleistocene age and dune and slope-wash cover of Holocene age. Stratigraphic sections of the Los Angeles Basin, Ventura Basin and the Santa Barbara Channel area are shown in Figures A-1, 2 & 3.

2. Description of Major Geomorphic and Bathymetric Features

a. Santa Rosa-Cortes Ridge

Emery (1960) calculates the part of the Borderland north of $31^{\circ}30'$N latitude covers an area of more than 30,000 square statute miles (about 80,000 km^2), but about 85% of this area is in water deeper than the 200-meter isobath. One of the largest features of the shallow water 15%, and the most persistent geomorphic feature on the Borderland east of the Patton Escarpment is the Santa Rosa-Cortes Ridge (Fig. II-2), which extends uninterrupted for approximately 210 km (130 miles) southeast from Santa Rosa Island to the southeast end of Cortes bank. This ridge lies between 100 im (60 miles) and 145 km (90 miles) off the mainland coast and is flat-topped and slightly asymmetric in that the slopes eastward into the Santa Cruz and San Nicolas Basins are gentler than those to the west. Along the northern half of the ridge, the crest is broad and less than 200 m (660 ft.)deep although a broad, shallow saddle more than 350 m (1,150 ft.) deep transects it at about midpoint. San Nicolas Island, the highest point on the ridge at 277 m (907 ft.) altitude, is situated on an east-trending salient. Tanner and Cortes banks from a shallow, double protuberance at the southwest end that culminates in Bishop Rock, a reef less than 4 m (15 ft.) deep. Another prominent ridge that projects above the 200-meter isobath bifurcates southeastward from Santa Cruz Island to form the Santa Barbara and Santa Catalina Island platforms.

b. Patton Ridge

Patton Ridge, a relatively shallow area just east of the north end of the Patton Escarpment, trends northwest in its southern part but is oriented nearly due north in its narrow northern part. This broad, curving ridge is nearly 110 km (70 miles) long and has banks as shallow as 218 m (715 ft.) in its east-central part. Another irregular, Y-shaped ridge system separates San Clemente Basin, East Cortes Basin and No Name Basin and includes Sixty mile Bank at its southern end, where the shallow point is 97 m (318 ft.) deep.

c. Marine Basins

Scattered throughout the rugged bottom topography of the Borderland are many basins (Figs. II-2, II-4). Beginning north of an arbitrary line from San Diego to Northeast Bank, there are four deep, silled basins, the floors of which are more than 1,000 ±m (3,300 ft.) below sea level. These are Santa Cruz Basin (maximum depth 1,350 m (6,450 ft.), San Nicolas Basin (maximu depth 1,827 m (5,995 ft.), Santa Catalina Basin 1832 m (6,012 ft.), and Tanner Basin (maximum depth 1,549 m (5,082 ft.). Part of a fifth basin, San Clemente Basin (maximum depth 2,107 m (6,913 ft.), extends into the area from the southeast; and a deep open-ended depression, San Diego Trough, drops off to to the southeast 1,253 m (4,131 ft.) deep west of Coronado Bank. Santa Monica and San Pedro Basins have much shallower floors, which in general are about 750 ±m (2,500 ft.) deep, although the deepest point in the Santa Monica Basin is 948 m (3,110 ft.) below sea level. The east-west Santa Barbara Basin is the shallowest, with a maximum depth of 600 m (2,050 ft.). Most of these elongate basins are rhomboid in outline, but both Santa Cruz and San Nicolas Basins taper to the southeast and San Clemente Basin is very irregular and poorly defined topographically. All are oriented approximately N45°W.

For comparison of size with onshore areas, San Nicolas and Santa Cruz Basins cover about 2,660 km^2 (1,027 miles^2) and 1,779 km^2 (687 miles^2), respectively, at sill depth, whereas the relatively flat part of the Los Angeles Basin extends over approximately 2,538 km^2 (980 miles^2) (Emery, 1960).

d. Submarine Canyons

One of the most unique and spectacular features of the Borderland is the number of large submarine canyons which traverse the shelf to the deeper basins (Fig. A-4). From south to north the major canyons are: Coronado Canyon at the border, La Jolla Canyon at the site of Scripps institute, San Pedro Valley in San Pedro Bay, Redondo Canyon, Santa Monica Canyon, Dume Canyon, Mugu Canyon and Hueneme Canyon, all draining the Santa Monica Bay portion of the coastline into the Santa Monica Basin. No large canyons drain into the Santa Barbara Channel.

Four large canyons drain from island shelves into deep basins. Santa Cruz Canyon has its head between Santa Rosa and Santa Cruz Islands, draining into Santa Cruz Basin. Catalina Canyon runs westerly from Catalina Island to Catalina Basin and San Clemente canyon has its head near the southeast tip of San Clemente Island draining southeasterly to San Clemente Basin. The head of Tanner Canyon lies between Tanner and Cortes Banks and trends southeasterly into East Cortes Basin.

Shepard (1963) has summarized the available information describing La Jolla, Scripps and Coronado Submarine Canyons.

> La Jolla and Scripps Submarine Canyons. Partly because of their location close to Scripps Institute of Oceanography, La Jolla Canyon and Scripps Canyon, a prominent tributary (Fig. A-5), are the best known in the world. The three tributaries at the head of Scripps Canyon have been explored extensively by aqua-lungers, and with the help of their photographs and descriptions along with extensive soundings and bottom sampling an accurate picture is now available (Fig. A-6). The innermost head of South Branch of Scripps Canyon lies only 230 m from the low

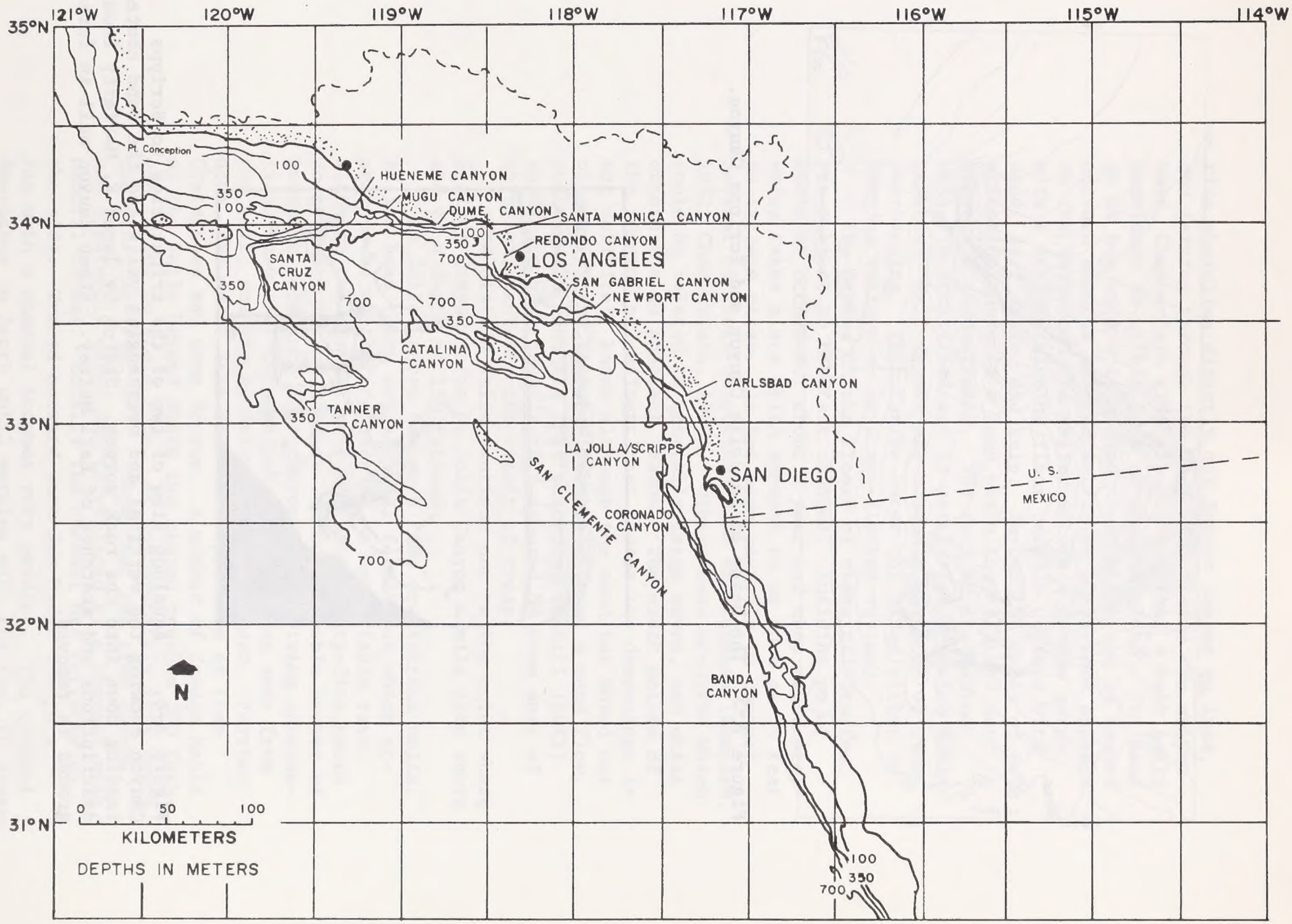


Figure A-4. Submarine Canyons of the Southern California Bight (SCCWRP, 1973).

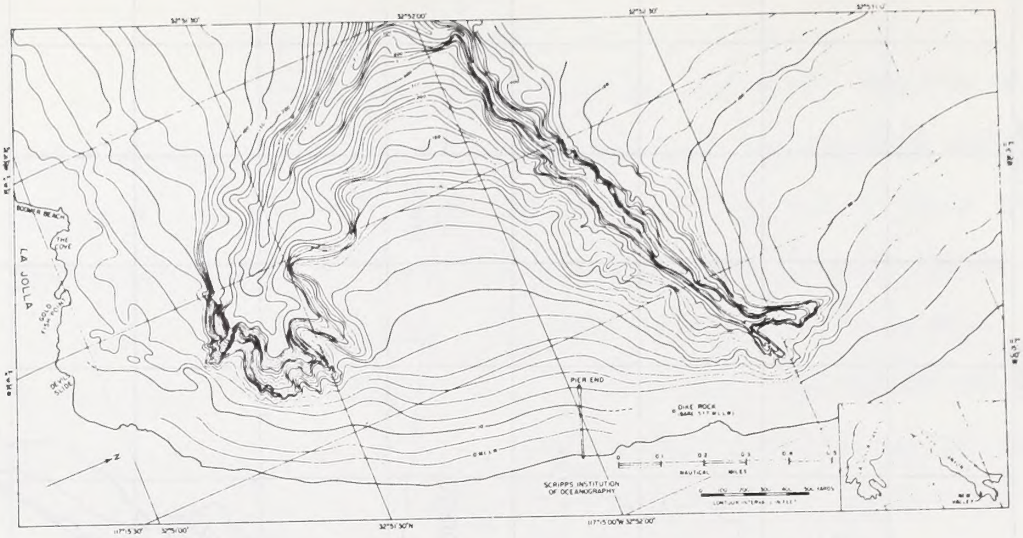


Figure A-5 The heads of La Jolla Canyon and Scripps Canyon.

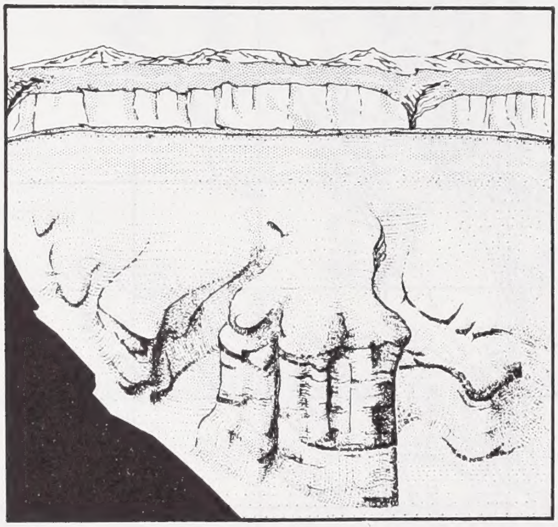


Figure A-6. Aqualung view of two of the tributaries to Scripps Canyon showing the vertical and overhanging walls and the sand chutes leading down into the rock gorges. Sketch by James R. Moriarty from descriptions and sketches of Earl Murray. Steep canyon wall in foreground is removed.

tide shoreline directly off Sumner Canyon on land, and jetting through the sand fill inside the canyon head, Chamberlain (1960) has shown that a rock gully continues to within 60 m of the shoreline. The head as it now exists is a sand chute which can be traced outward about a hundred meters to where rock appears on the walls and the valley enters a narrow gorge with a steeply sloping floor usually covered with sand, surf grass, and kelp. Beyond the depth of wave agitation there is a zone where the kelp and surf grass are concentrated. The rock on the canyon walls is stratified and is partly covered with marine growths. Wall slopes are commonly vertical or even overhanging. Tributaries enter the sides either as hanging valleys or as steep-floored ravines.

The depths on the floors of these tributaries are subject to constant changes. Building up of sediment occurs for about a year and then rapid deepening takes place which amounts to as much as 50 feet in extreme cases. It has been possible to connect several of these deepenings with earthquakes (Shepard, 1952; Chamberlain, 1960). Others have occurred which could be related to unusually large waves, and still others for no apparent reason. The exact nature of the removal of sediment that causes the deepenings is not definitely known although the sand has moved out of some of the tributaries, probably as a sand flow, and exposed channels that according to Dill (1962) appear to have been freshly scoured by some sort of abrasion, probably the result of creep.

The cliffed walls continue out to the point where Scripps Canyon joins La Jolla Canyon a mile from shore and at a depth of 150 fathoms.

La Jolla Canyon has much less precipitous walls. At its head there are alluvial formations which appear to be weathering back at an appreciable rate although the surveys over the past twenty-five years do not show marked changes. A considerable number of branches come into this canyon head. Diving observations show that large blocks are breaking away from the wall, and the alluvium is being eroded. Farther down, the walls have rock outcrops, some of them Cretaceous and some Eocene. A number of dredge hauls on the walls beyond where the canyon reaches 300 fathoms failed to yield rock. At approximately this depth the profiles (Fig. A-7 show that the true canyon has apparently ended and is replaced by a channel with natural levees. Locally the channel has terraces on the side. Traced outward into San Diego Trough a fan with a channel becomes very evident. The channel decreases in depth until merging with the fan, it disap-

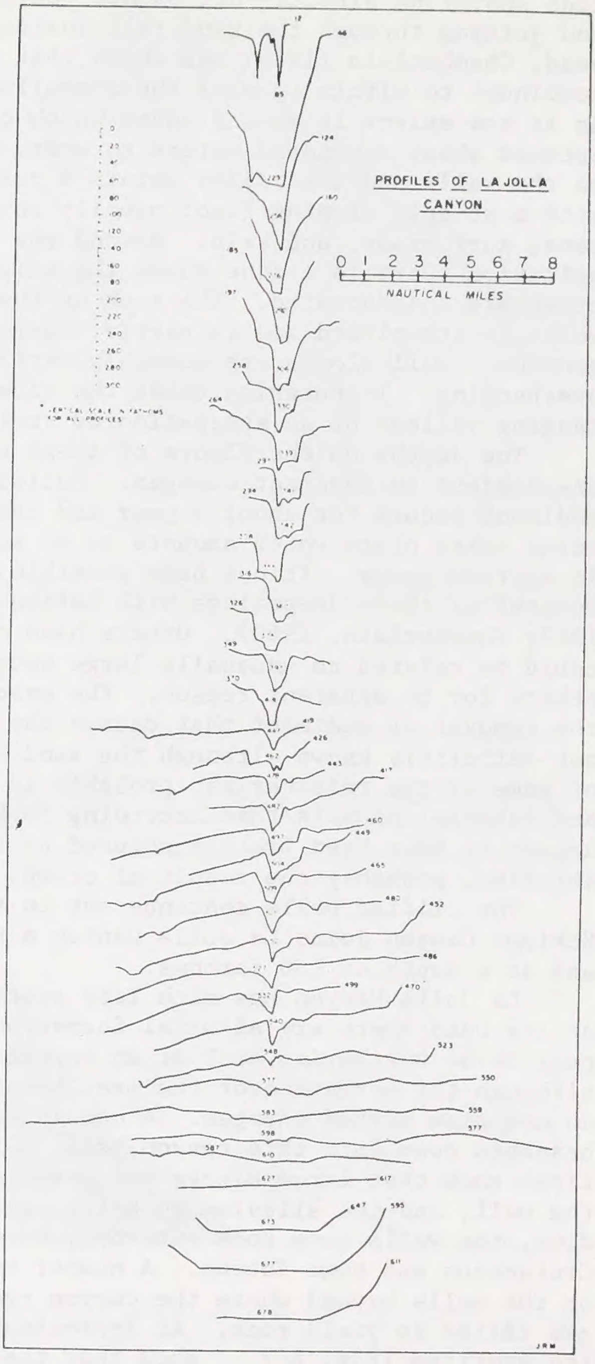


Figure A-7. Profiles from fathograms along the length of La Jolla Canyon and across the fan-valley that cuts the fan out beyond the rock-walled canyon.

pears in the flat floor of the trough.

Cores along the length of La Jolla canyon beyond the confluence with Scripps Canyon show alternating layers of sand and silty clay. The same types continue all the way out to the end of the channel. Sand layers, however, are found also in the fan and on the levees on either side of the channel although the sand is somewhat less common.

Coronado Canyon. A canyon occurs off the United States-Mexican border starting at a distance of 8 miles from the Tijuana River mouth. Near its head there is a northern tributary called Loma Sea Valley with a divide, beyond which the slope is reversed (Fig. A-8). Apparently Coronado Canyon has cut across the rocky Coronado Bank and pirated a valley which formerly drained to the northwest along Loma Sea Valley. Where Coronado Canyon extends west across the ridge it has steep rocky walls and a narrow V-shaped gorge but beyond, where it turns rather abruptly to the south, its outer wall consists of a sediment-covered ridge with irregular hummocks suggesting landsliding although a little shale was found in dredgings near the base of the bank. The outer wall was formerly interpreted as an old delta, but it might also represent a high natural levee built on top of a low rock ridge. Slumping of either a former delta or levee has taken place. The valley floors both in the rock canyon and in the channel beyond contain a fill with layers of sand alternating with silty clay. Beginning directly west of North Coronados Islands there are layers of shell and shallow water form sand on the channel floor which closely resemble the sediment found on the narrow shelf off this island. On the other hand, some coarse sand containing fine gravel found on the canyon floor nearby is distinctly different from that on the adjacent shelf.

Traced seaward the valley leaves the base of the rocky slope off the Coronados Islands and is found to have low natural levees on both sides. This valley winds across the southern end of San Diego Trough. As it approaches a rocky ridge the channel is cut considerably deeper below the floor than upstream, but this gorge does not persist all the way down into San Clemente Basin. It appears that the local deepening of the valley is related to the crossing of the ridge.

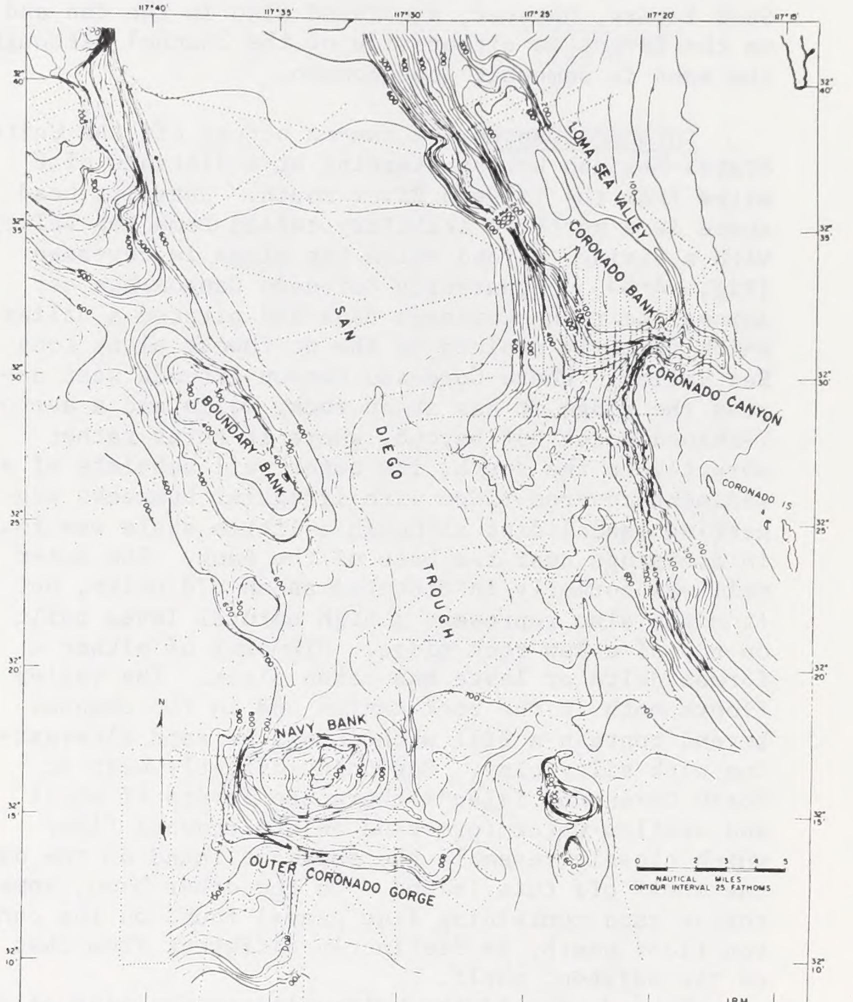


Figure A-8. Contour map of Coronado Canyon and its outer continuation across San Diego Trough and across a rocky ridge west of the Trough. Note the increase in depth as the valley crosses the outer ridge but the disappearance of all trace of the valley on the slope extending into San Clemente Basin. The canyon head crosses a ridge very much as do antecedent streams. It appears to have captured the drainage of Loma Sea Valley. Sounding lines shown by dots.

3. The Shallow Continental Shelf and Its Sediments

A description from Point Conception to the Mexican border follows, adapted from Allan Hancock Foundation (1965).

a. The Point Conception Narrow-Shelf Complex

From Point Arguello to Santa Barbara Point the shelf is relatively narrow, averaging 6.4 km (4 miles) in width, and extending 80 km (50 miles) along the portion of the coast bordered by the Santa Ynez Mountains. The trends of the mountains and the shelf are east-west, with Point Conception protruding south-westward as a prominent physiographic feature.

This shelf is characterized by a complex sediment textural pattern. The bottom materials are highly variable in size and have a very patchy distribution.

Between Point Arguello and Point Conception, the sediment type is mostly sandy silt, but a progression outward from very fine sand to silt is revealed by median diameters. The samples closer to shore are better sorted than those in deeper water.

Between Point Conception and Gaviota, a blanket of sand and silty sand covers the shelf to a water depth of 91 m (300 ft.). Nearest the point it is very fine sand. Farther to the east it grades into fine sand.

b. The Santa Clara River Area

Between Point Las Pitas and Port Hueneme, sediment types are silty sands near the mouth of the river and progressively become finer (through sandy silts to silts) with increasing distance from the Santa Clara River.

The silts occur as far as 16 km (10 miles) westward from the river mouth.

The sediments are well sorted near shore, have average sorting farther seaward, and become poorly sorted about 12 km (7 1/2 miles) from the mouth of the river. Apparently wave action is not sufficient to distribute the sediments evenly owing to the great abundance of material supplied by the river. A surplus of fine grains in small quantities is the result. Sediments from the outer part of the prodelta contain quantities of plant fragments that have been carried to sea from the Santa Clara River and deposited with the fine-grained sediments near the edge of the shelf.

c. The Santa Monica Shelf Complex

The sediments of Santa Monica Bay are silts on the east-west trending part in the northern section of the bay, sandy silts in the vicinity of Santa Monica, and sands and sandy silts grading southward to finer sediments from the mouth of Ballona Creek to Redondo Submarine Canyon. This progression to finer grained materials probably represents the contribution of sediment entering the bay by way of Ballona Creek. Ballona Creek does not drain a large watershed now, but was formerly the outlet of the Los Angeles River before it changed its course in the latter part of the last century.

A central plateau produces a westward bulge of the depth contours. This central plateau, with its anomalous coarse sediments at a great distance from shore, contains abundant glauconite, phosphorite, shell material, and rock fragments (Terry, Keesling, and Uchupi, 1956). It is a region that has not yet been covered by modern sediments, and the authigenic and organic materials have thus accumulated. Scattered patches of bedrock project through the sedimentary cover. In comparison to the smooth gently sloping sea floor of the rest of Santa Monica Bay, the central plateau is a region of relatively rugged and irregular micro-topography (Terry and Stevenson, 1957).

Median diameters in Santa Monica Bay show a progression from fine sands to coarse silts in the northern part of the bay. The contours of medians bulge seaward south of the mouth of Ballona Creek. Most of the sediments on the central-plateau region are very fine sands (medians 0.062 mm. to 0.125 mm.), but some scattered samples are coarser than 0.20 mm. The coarse silt extends between the Ballona Creek sand and the central plateau sands.

Almost all of the deposits in the bay, with the exception of those on the central plateau, are well sorted. Sediments on the central plateau are poorly sorted, owing to (1) the lack of wave action at those water depths, (2) multiple sediment origin, (3) development of authigenic materials, (4) shell debris, and

(5) rock fragments which were eroded and rounded during a lower stand of the sea. The presence of gravel in some samples also contributes to the poor sorting.

d. The San Pedro Shelf Complex

The sediments of San Pedro Bay are mostly sands and silty sands from the shore to the edge of the shelf. One patch of sandy silt occurs off Huntington Beach, and finer sediments exist behind the Los Angeles Harbor breakwater. In the center of the bay are outcropping Middle Miocene shales, limestone, and sandstones (Moore, 1954) that have contributed coarse debris to the sediments on that part of the shelf.

Median diameters show the sediments as very fine sands, with an area of coarse silt off Huntington Beach and fine sand off Alamitos Bay. Sediments in the shoreward part of San Pedro Bay have average sorting and seaward they are well sorted. The fine-grained deposits behind the breakwater are poorly sorted.

The coarse fractions of most of these samples are gray micaceous quartz and feldspar sands, but a concentration of "red sands" and mixtures of red and gray sands occur near Alamitos Bay where the bottom is 20 to 40 feet deep. These red sands consist of angular grains of fine and medium sand, about half of which are stained red by a thin coating of iron oxide. Their nearshore occurrence indicates a zone of non-deposition in the vicinity of the mouth of Alamitos Bay, for the red sands are relic materials deposited under environmental conditions of lower sea level.

A second deposit of red sand is the rocky area on the central San Pedro Shelf. This sand is coarser than that near Alamitos Bay and owes its origin to the erosion of a Pleistocene sandstone cropping out on the sea floor (Moore, 1954).

e. The Oceanside Narrow-Shelf Deposit

The mainland shelf from Newport to Point Loma is narrow in comparison to most of the Southern California shelf. The average width is 4.8 km (3 miles) and the maximum is 9.7 km (6 miles). Sediments on this shelf show a regular progression from sands along the shore to silts offshore. Median diameters show that the sediments close to shore are very fine sands. The rest of the shelf deposits, as far south as Carlsbad, are coarse silts with median diameters rarely less than 0.040 mm.

The correlation of median diameters with water depth indicates that the shelf between Corona del Mar and Carlsbad has been strongly influenced by waves which move finer material progressively farther from shore. The nearshore coarser sediments are well sorted whereas those in deeper water have average sorting.

The shelf between Carlsbad and La Jolla is somewhat different from the area to the north. The sediments are coarser, being mostly sands and some silty sands. Median diameters are in the very fine sand range. Most of the sediments have average sorting with no correlation of sorting with water depth.

The low efficiency of the ocean in reworking and moving sediments in the area of Carlsbad may be partly the result of the protection afforded by the projecting point of land at La Jolla. Such a projection may cause wave refraction to the extent that sedimentary debris is kept in suspension and transported beyond the shelf. The Carlsbad-to-La Jolla shelf has coarser material than adjacent regions. A possible explanation is that the sediments are lag deposits left by an advancing shoreline and remain uncovered by modern detrital materials.

Median diameters on the shelf between La Jolla and Point Loma show medium sands around Point La Jolla and a general decrease in grain size both seaward and southward along the coast. Seaward, the sediment grain size decreases to coarse silts in water depths of 91 m (300 ft.). Southward, very fine sands occur in the vicinity of the mouth of Mission Bay, and coarse silts blanket the outer half of the shelf southward as far as Point Loma.

f. The San Diego Shelf Complex

The segment of the mainland shelf from Point Loma to the border of Mexico is nearly twice as wide (about 16 km (10 miles) as the region immediately to the north. Its sediment distribution shows a marked variation from the narrow shelf segments, because the sediment types are almost exclusively sands and silty sands. In this respect, the San Diego Shelf is similar to the San Pedro Shelf. One area of sandy silt occurs on the inner shelf near the Coronado Strand. This fine-grained material has probably been transported by man in dredging San Diego Bay. Most of the wide San Diego Shelf consists of fine to medium sands, but the fine sands are located along the shore, and the medium sands are in deeper water.

The San Diego Shelf has two markedly different kinds of sediment. One is a fine gray sand and the other is a medium to coarse brown sand, which is similar in appearance to the "red sand" in San Pedro Bay (near the mouth of the San Gabriel River), and also in Santa Monica Bay (near the mouth of Ballona Creek). In contrast to the latter areas, however, the red sands in the San Diego region extend to water depths of 91 m (300 ft.). Coarse fractions of the gray sand are similar to coarse fractions of sediments on the narrow shelf to the north, but the fact that gray sand extends seaward to the 91 m (300 ft.) water depth contour is in contrast to the Oceanside Shelf, where the outer limit of sands is about 15 m (50 ft.). In addition, the gray sands on the San Diego Shelf are considerably farther from shore than the Oceanside Shelf sands. These points suggest the gray sands are not modern detrital materials, but rather that the gray sands were left behind after being reworked by the advancing shoreline towards the end of the Pleistocene.

Sediment sorting and skewness, as well as average grain size, indicate that materials in the vicinity of San Diego have not been deposited under the present environmental conditions. Sediments on the outer two-thirds of the shelf near the Mexican border are considerably coarser, having medians greater than 0.250 mm. than those nearer shore. The sand content is greater than 98%, and the color is red to brown, in marked contrast to the gray sands and silts that surround them and the olive-green sediments of most of the mainland shelf. The red color is an iron-oxide coating on the outer surfaces of approximately half of the angular quartz and feldspar grains.

The red sand most likely is a relic deposit of sediments laid down when sea level was approximately 91 m (300 ft.) lower and the main-

> land shelf was exposed to subaerial processes. As sea level subsequently rose, these deposits were reworked and redistributed by the advancing sea, and the gray sands were left behind as a tail of beach and nearshore material. The two types of sand have remained uncovered, except where sediments from the Tijuana River have been deposited on the inner shelf.

Figures A-9, 10, 11, and 12 depict the distribution of mainland shelf sediments between Point Arguello (North of Point Conception) and the Mexican border. General sediment distribution around the Channel Islands and in the deeper portions of the Borderland is shown in Graphic 13.

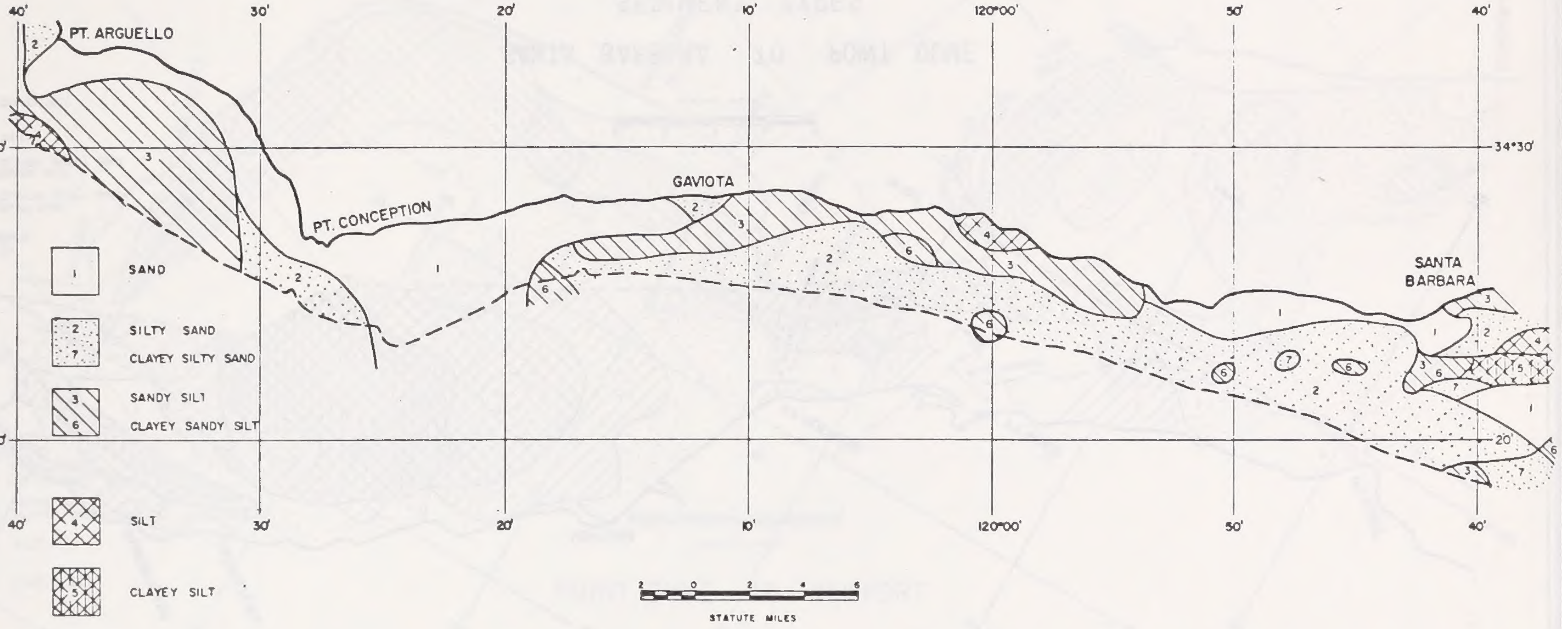
4. Faults and Folds

A tectonic map showing the principal faults and folds between Point Arguello and the Mexican Border is illustrated in Graphic 12. Indicated on the graphic also are areas of known oil seeps.

Faults

Numerous dip-slip, strike-slip, oblique-slip and reverse faults are indicated. Many of the offshore faults are only sporadically mapped, hence their locations are partially inferred. The longest continuously mappable fault is the Santa Ynez, which extends for 140 km (90 miles) along the north edge of the Santa Ynez Mountains. Near its western end, a southwest-trending branch shows evidence of late Quaternary movement (Ziony et al., 1974).

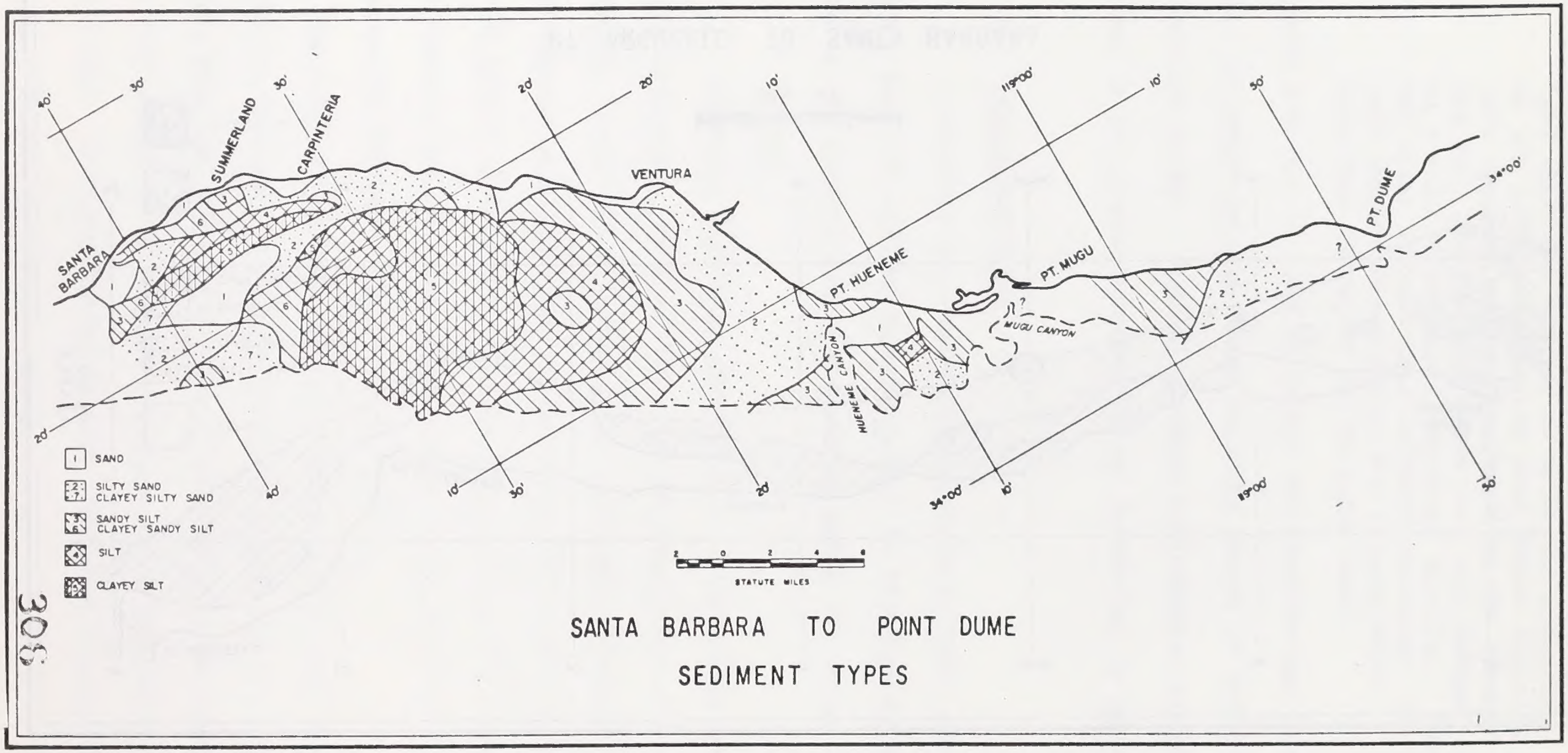
On the northern Channel Islands, faults with a west or northwest trend are the dominant structural features (Weaver et al., 1969). Both Santa Rosa and Santa Cruz Islands are cut by large median faults each of which seems to be a major structure with considerable left-lateral offset. Inferred faults beneath the Santa Barbara Channel have



PT. ARGUELLO TO SANTA BARBARA

SEDIMENT TYPES

Figure A-9
(ALLAN HANCOCK FOUNDATION, 1965)



SANTA BARBARA TO POINT DUME

SEDIMENT TYPES

Figure A-10
(ALLAN HANCOCK FOUNDATION, 1965)

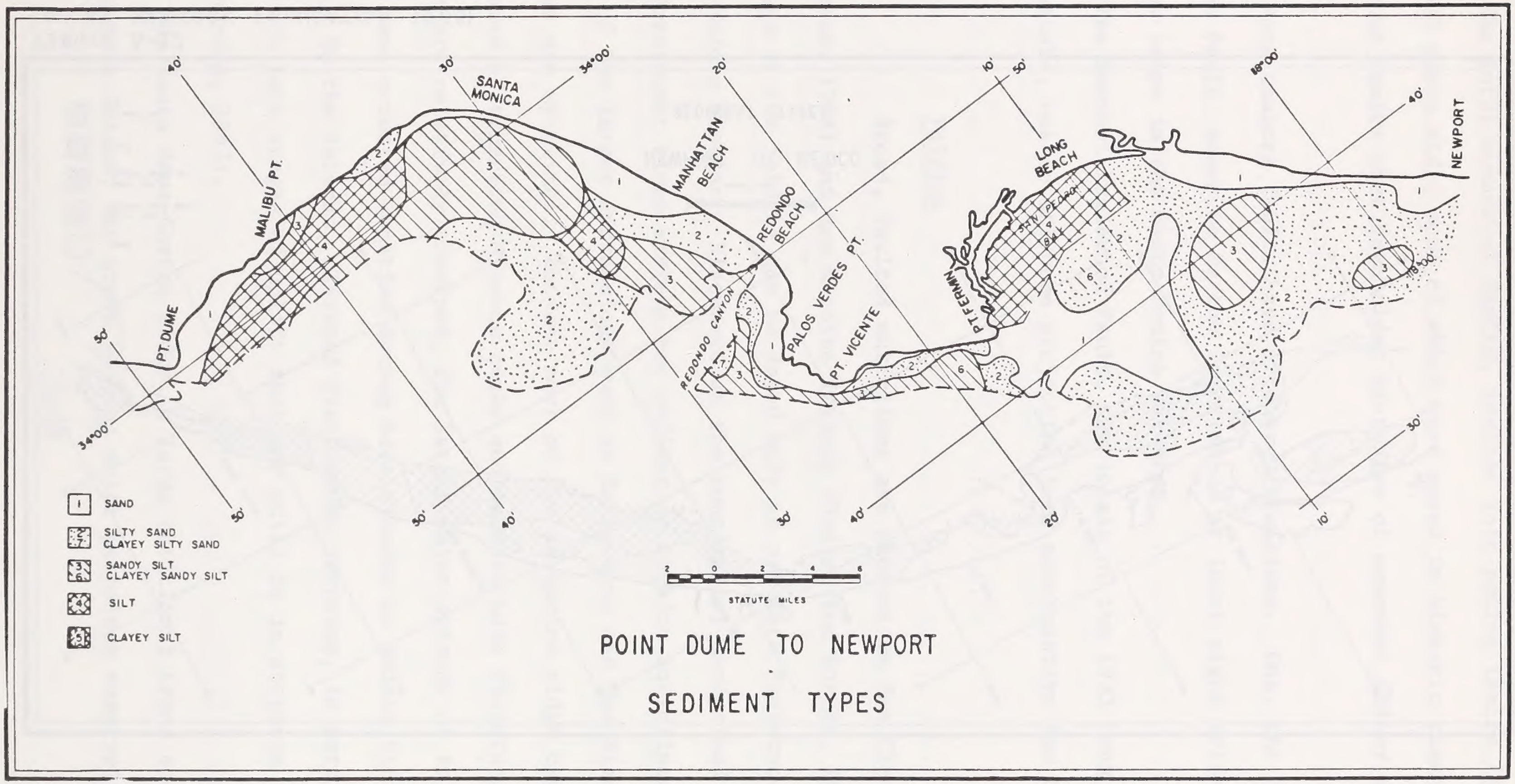


Figure A-11
(ALLAN HANCOCK FOUNDATION, 1965)

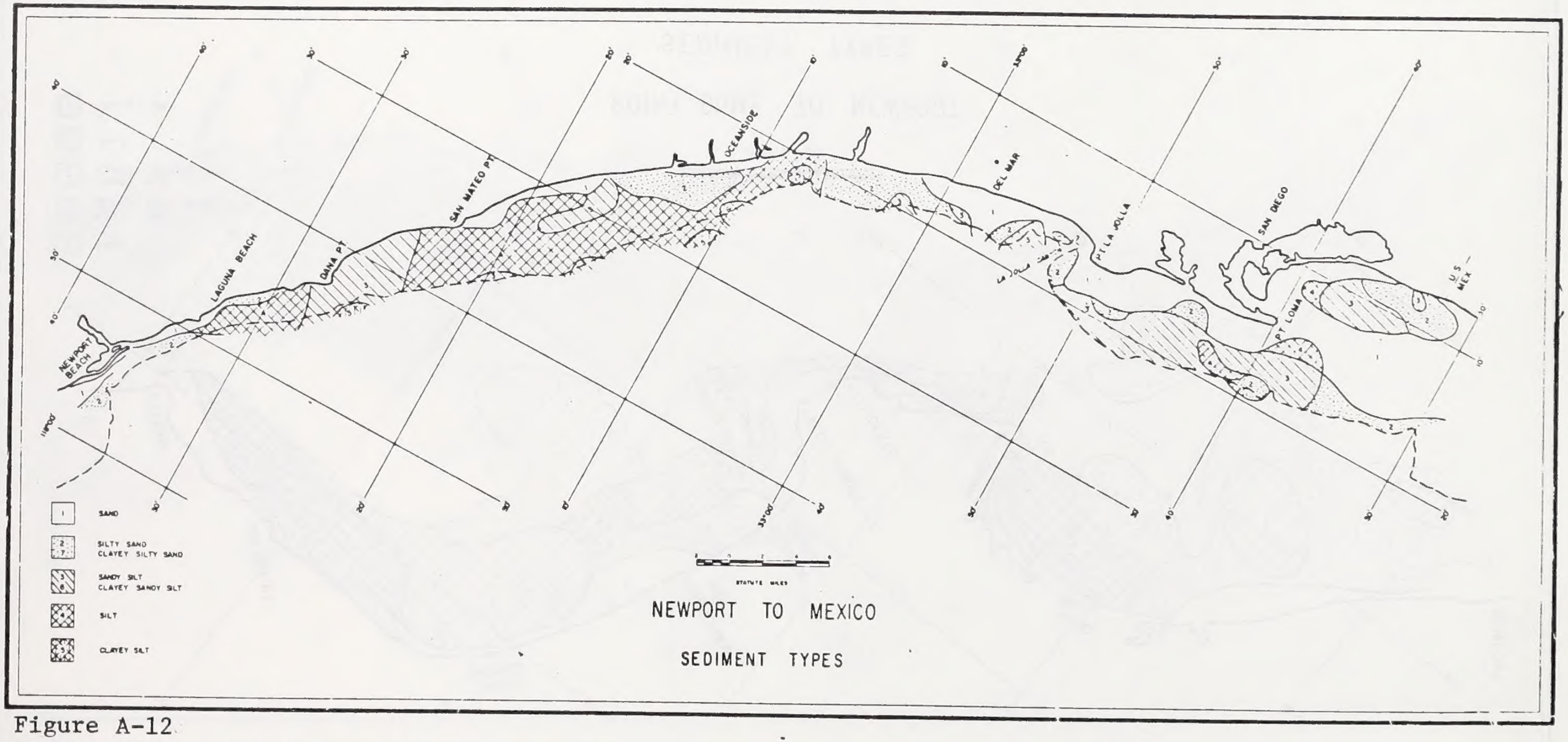


Figure A-12
(ALLAN HANCOCK FOUNDATION, 1965)

similar east-west trends (Curran et al., 1971; Lee and Vedder, 1973).

The total number of faults, include both active faults (less than 500,000 years old), some of which have moved in historic time; and numerous faults that have older histories of movement (Ziony et al., 1974).

Many onshore faults have offshore extensions. One, the Palos Verdes Fault, seems to be the location of at least eight offshore petroleum seeps in the Santa Monica Bay area.

The Newport-Inglewood Fault, the locale of the 1933 Long Beach earthquake, has an offshore projection into southeastern San Pedro Bay.

Folding

Broad, faulted anticlines are present on San Clemente (Olmsted, 1958) and San Nicolas Islands (Vedder and Norris, 1963), but the age of the folding can be dated only as pre-Late Pleistocene and post-Middle Miocene. Elsewhere on the continental Borderland many of the persistent ridge systems may reflect *en echelon* anticlines and some of the larger depressions such as Santa Cruz and San Nicolas Basins are synclinal. Because most of the submarine ridge crests are composed of truncated Miocene rocks and because Late Pleistocene surfaces are relatively unwarped, the latest major episode of folding must have occurred sometime during Late Miocene to Middle Pleistocene time. On the islands, elevated Pleistocene terraces, in part eustatic, indicate late stages of uplift that may still be in progress (Vedder and Norris, 1963).

The Santa Rosa-Cortez Ridge, a large anticlinal trend southeast of Santa Rosa Island, may prove to be a major petroleum reservoir. The trend, over 100 km (62 miles) in length and 210 km (130 miles) in width, terminates in the plunging anticlinal nose south of San Nicolas Island.

Many structural features similar to the productive Rincon Trend and Molino Trend, both of the Santa Barbara Channel, are found northeast of San Miguel Island, west of San Nicolas Island, south of Point Fermin, and south of San Clemente Island.

Representative U. S. Geological Survey structural cross sections for the Borderland are shown in Graphic 14.

5. Geologic Hazards

a. Historical Record of Earthquakes in Southern California

The seismic history prior to the installation of seismographs is given by numerous written descriptions of earthquake effects. Reliable accounts of California earthquakes date from about 1800. The earliest reports are found in notes of Spanish explorers and early settlers, and in the records of the Franciscan Missions. The U. S. Geological Survey (1974) summarized the records of all major earthquakes felt in the Santa Barbara Channel region which comprises the northern portion of the Borderland. This summary of earthquakes is presented in Appendix 13. The summary applies equally well to document the major quakes felt throughout the entire Borderland as Santa Barbara is less than 322 km (200 miles) from any other portion of the Borderland.

Four of these earthquakes were especially destructive in the Channel area. The earliest, in 1812, destroyed Missions Santa Barbara and Purisima Conception (about 16 km (10 miles) northeast of Point Arguello) and caused a tsunami along the north coast of the Santa Barbara Channel. Reported estimates of the high-water mark of this tsunami were as much as 15 m (50 ft.) near Gaviota. A recent detailed study (Marine Advisors, Inc., 1965) of historic records, however, concludes that such accounts are unsubstantiated and cannot be accepted at face value. Several asphalt (crude oil) springs reportedly began to flow at places inland from the coast, and a burning oil spring near Rincon Point was enlarged. In the area of Santa Barbara the destruction had a Rossi-Forel intensity of IX to X. The reported damage and other effects resemble those accompanying other California earthquakes of magnitude 7. An oil spout also was observed at the shoreline near the west end of the present Summerland oil field one night after an earthquake in 1883 (Goodyear, 1888).

An earthquake on June 29, 1925, caused widespread damage in coastal communities from Pismo Beach to Ventura and killed twenty people. Almost the entire business section of Santa Barbara was destroyed or rendered unsafe. The damage was estimated at $6 million and this figure does not include damage to residences. Mission Santa Barbara again was heavily damaged with partial destruction of two bell towers, collapse of the front facade, and failure of some older interior adobe walls. No damage was reported to wells in the nearby Summerland oil field. Most of these wells were located on piers which extended offshore. Nunn (1925) reports that crude oil was extruded through beach sand at several points along the Santa Barbara coast at approximately the same time as a series of slight foreshocks began, about 3 hours before the main earthquake. The epicenter of this magnitude 6.3 earthquake was probably less than 16 km (10 miles) southwest of Santa Barabara.

A third major earthquake occurred on November 11, 1927, northwest of the Channel off Point Arguello (Byerly, 1930). This shock, with a magnitude of 7.5, ranks as the second largest California earthquake since the San Francisco earthquake of 1906. Effects were most pronounced at Surf and Honda, just north of Point Arguello, where people were thrown from their beds, the concrete highway was cracked, a railroad bridge was damaged, and several hundred thousand cubic feet of sand were shaken down from a beach cliff. Buildings were damaged along the coast from Cambria, about 129 km (80 miles) northwest of Point Arguello, to Gaviota 45 km (28 miles) to the east. A seismic sea wave was generated by the main event, and seismic disturbances from the main shock and some of its stronger aftershocks were felt by ships at sea. The seismic sea wave, or tsunami, was observed at Surf and Pismo Beaches, 16 and 64 km (10 and 40 miles) respectively, north of Point Arguello. The wave was at least 1.8 m (6 ft.) high and resembled a large storm wave. At Port San Luis (Avila) near Pismo Beach, a 1.5 m (5 ft.) wave was followed by one hour of water agitation. Tide gage records at San Francisco and San Diego confirm this tsunami.

The last of the four destructive earthquakes in the channel area occurred on June 30, 1941. Its magnitude was 5.9 - 6.0, and its epicenter was located in the Santa Barbara Channel about 8 km (5 miles) south of the coastline between Santa Barbara and Carpinteria. Several communities along the Santa Barbara coast were damaged.

The historic records of the Borderland document numerous periods characterized by sequences of frequent or nearly continuous low-magnitude seismic activity without exceptionally large shocks. Such sequences are called "earthquake swarms" and are commonly associated with volcanic activity; however, there is no evidence of a volcanic origin for the earthquake sequence in the Borderland area.

A more distant earthquake, but one that strongly shook the northern part of the Borderland (Wood, 1955) occurred January 9, 1857. Its epicenter was on the San Andreas fault near Fort Tejon, about 74 km (46 miles) north of the San Fernando Valley. The surface faulting that accompanied this earthquake was not mapped at the time, but contemporary accounts and recent geologic studies (Wallace, 1968; Vedder and Wallace, 1968) demonstrate substantial right-lateral displacement on a fualt break at least 241 km (150 miles) long. The effects of this earthquake are comparable to those of more recent earthquakes of about 8.0 magnitude. Early descriptions indicate that all the houses in Santa Barbara were damaged (Wood, 1955) along with many houses in Los Angeles, and that shaking in the Santa Clara River Valley east of Ventura was severe. Differential subsidence occurred in the river bed, and long cracks formed from which water was ejected to heights of 1.8 m (6 ft.).

Another earthquake that shook the Borderland occurred on February 9, 1971. Its epicenter was about 14 km (9 miles) northeast of the city of San Fernando, the focus was 13 km (8 miles) beneath the surface and the magnitude was 6.6. A discontinuous fault scarp was formed in the vicinity of the cities of San Fernando and Sylmar. In the Santa Barbara Channel region and Los Angeles, damage from this shock was minimal but in the San Fernando Valley the effects were disastrous. Sixty-four persons lost their lives and tangible damage was estimated at

$553,000,000. Nearly 25,000 buildings were damaged or destroyed, five highway overpasses collapsed and seven others were damaged, four hospitals were severely damaged or destroyed, and five dams suffered major damage. (U. S. Geological Survey Professional Paper 733, 1971).

Oil and gas installations in the Los Angeles area largely escaped severe damage from the San Fernando earthquake (Oil and Gas Journal, 1971). Only one small refinery (5,500 barrels/day) is located near the earthquake epicenter (about 18 km or 11 miles). It was forced to shut down temporarily because of damage to storage tanks and pipelines. A number of oil fields in the earthquake area shut down immediately after the quake but were returned to production within a day or two. Damage to gas lines was limited to an area of 10.4 km^2 (4 square miles) in the northeast corner of the San Fernando Valley.

Operators of all federal public and acquired land leases in Los Angeles and Ventura Counties were required by the U. S. Geological Survey to report damages resulting from the San Fernando earthquake. Some federal leases are within 16 km (10 miles) of the epicenter. There was no significant damage to the production facilities or producing wells on the twenty federal leases on which reports were received. Geological Survey personnel inspected all of these leases. Several of the leases had some earth slides, but the slides caused no damage. The total damage on government leases was minor and was estimated at about $6,000; about half of this was damage to roads.

The relatively light damage sustained by petroleum production and refinery facilities was most probably due to the geographic relationship of those facilities to the earthquake fault break. Although the

Newhall refinery is almost the same distance from the epicenter as the most heavily damaged areas, the latter were located along the surface fault break. The greatest structural damage was concentrated along the surface rupture, in areas of locally amplified seismic shaking, and in tectonically deformed areas in the thrust plate above the faults with surface rupture (U. S. Geological Survey, 1971, p. 75). Thus, the San Fernando earthquake clearly demonstrates the importance of recognizing the location of active fault scarps and the tectonic nature of movement on a fault system.

A break in a pipeline near the Van Norman Dam, although not on federal government land, was investigated by the Geological Survey. Excavation and inspection of the pipeline revealed that the breaks were at acetylene welds in the old (1924) line; an electric-arc-weld (now used in pipeline construction) was removed and analyzed as perfect.

The most recent major earthquake in the Southern California area occurred on February 21, 1973 when a magnitude 6.0 earthquake centered near Point Mugu shook the Borderland region. The focus was about 17 km (10 miles) beneath the surface. Although the earthquake was felt over a wide area of Southern California--as far away as San Luis Obispo, Bakersfield, Barstow, Indio, and San Diego--there were no deaths and injuries were minor. The maximum horizontal acceleration recorded was 0.13 g at Port Hueneme, approximately 26 km (16 miles) from the earthquake focus. Damage has been unofficially estimated at $1 million. Structural damage was confined to old unreinforced masonry structures. While most of the structural damage was minor, several buildings in the city of Oxnard were severely damaged. Damage to newer, earthquake-resistant buildings was mostly confined to suspended ceilings, light fixtures, partitions, and windows (Takahashi and Schneite, 1973).

Teng and Henyey (1974) of the USC Geophysical Laboratory have analyzed all earthquakes with epicenters in the greater Los Angeles area between January 1 and December 31, 1973. They report a total of sixty-one (61) detectable earthquakes with the following distribution: fifty had magnitudes between 2.0 and 4.51, eight had magnitudes less than 2.0 and three had no calculated magnitudes. Seven of these, all with magnitudes less than 4.0, were located in Santa Monica Bay; four, with magnitudes less than 4.0, were located in San Pedro Bay, and the remaining fifty were either beyond the 500 m contour or in the eastern Santa Barbara Channel.

Of the fifty earthquakes with magnitude between 2.0 and 4.5, thirty were less than 3.0; nineteen were between 3 and 4.0 and only one greater than 4.

Recent Deformation

Very little information exists on which of the numerous Borderland faults are active. Certain faults which are tied into earthquake epicenters are assumed to be still deforming, but motion on the majority of faults is unknown. Those which have been studied include: the Santa Ynez fault zone, which trends westward for about 140 km (90 miles) along the northern margin of the Transverse Ranges, exhibits some physiographic evidence that suggests recent movements, and it has been considered an active tectonic feature by some geologists (Page et al., 1951). The magnitude 7.5 earthquake off Point

Arguello in 1927 may have occurred on the westward extension of the Santa Ynez fault zone.

The Big Pine fault, a major left-lateral fault with oblique slip near its western end, may have had measurable movement during historic time. The Southern California earthquakes of November 1852 were accompanied by about 48 km (30 miles) of surface faulting in Lockwood Valley (Townley and Allen, 1939) about 64 km (40 miles) northeast of Santa Barbara. The exact trend location of the surface faulting is unknown, but geologic evidence and contemporary reports indicate that it may have been along the Big Pine fault. Independent evidence of very young movement along the fault includes scarplets that cut Quaternary terrace deposits and apparent left-lateral offset of stream channels (Vedder and Brown, 1968).

Recent topographic surfaces and very young rock units have been deformed. In the Ventura anticline, lower Pleistocene strata form the upper part of a sedimentary sequence that is more than 12,200 m (40,000 ft.) thick. These lower Pleistocene beds dip 35 to 60 degrees on the south flank of the anticline, and, because they conformably overlie older rocks, they provide clear evidence that the structure has been formed since early Pleistocene time.

At Loon Point, 10 km (6 miles) east of Santa Barbara, upper Pleistocene alluvial fan deposits are tilted and cut by a northeast-trending thrust fault that offsets the base of the oldest fan by at least 122 m (400 ft.) (Lian, 1954). This faulting may have continued into Holocene time. Faulted terrace deposits are well exposed about 3 km (2 miles) southeast of Carpinteria, where highway cuts reveal a southwest-dipping

(40 degree) reverse fault that juxtaposes upper Pleistocene marine terrace deposits and highly deformed Tertiary sandstone and siltstone. This fault may also cut the present topographic surface; it may have moved during Holocene time. The California Division of Mines and Geology (1973) has published a fault map of the state. This shows no known historically active faults in the offshore Borderland area. It should be noted, however, that detection of subsea faults and particularly the movement along them is much more difficult than it is on land. In certain instances epicenters seem to be related to inferred faults in the Borderland.

b. Future Earthquakes

Although the Southern California Borderland is not known to have been the site of a great (magnitude 8.0) earthquake, the historic record previously presented shows that it has experienced several severe shocks. In addition, the geologic record shows that a high level of tectonic activity has continued at least through late Tertiary and Quaternary time in portions of the Borderland. The history of destructive earthquakes provides an indication of what might happen in the future, but due to the small number of such events the record does not provide a statistically reliable basis for prediction. In many areas, the number of large earthquakes that occur in a region is simply related to the number of small earthquakes. More specifically, the numbers of shocks of different magnitudes are related by the equation: $\log_{10}N=a-bM$ where M is the Richter magnitude, N is the number of events greater than magnitude M, and a and b are constants that vary with the seismic region being considered (Richter, 1958).

Allen et al. (1965) found that for the portion of Southern California encompassing the region between Bishop and Ensenada, smaller earthquakes provide a fairly good estimate of the rate of occurrence of the larger events. They calculated that on the average, a magnitude 6.1 earthquake should occur each year in this entire region, and a magnitude 8.0 earthquake should occur once in 52 years. Such a great earthquake anywhere in Southern California probably would have destructive effects in the Southern California Borderland. Its aftershocks, many of which also would be destructive, might be expected to affect an area the size of Southern California.

The record of small shocks could also be used to estimate the frequency of occurrence of large earthquakes in the Borderland area. However, Allen et al., (1965) found that for other areas of Southern California such an analysis was unreliable and in some places misleading. The best indicator of future activity in the Borderland, then, is the historic record. Estimation of the earthquake risk in the Borderland region depends on 1) the location of a given site relative to specific active faults; 2) the magnitude of expectable earthquakes on these specific faults; and 3) the occurrence rate of damaging earthquakes. Since 1925, there have been five earthquakes with magnitude 6.0 or greater in the Borderland and associated onshore area. These were 1925 and 1941 in the Santa Barbara Channel, 1933 at Long Beach, 1971 in Sylmar and 1973 at Point Mugu. Therefore, based on previous earthquakes, a magnitude 6 earthquake can be expected once every ten years (five in 50 years). Thus it is likely that proposed lease lands in the Southern California Borderlands will be subject to seismic shaking during their operational lifetime. Proper design of platforms will be dependent on geological factors which will influence the structural integrity during earthquakes.

The degree of seismic wave application to be anticipated in soft and unconsolidated sediment (underlying platform) will need to be examined in site locations. The possible presence of unconsolidated water saturated sands that could become "quick" under seismic shaking may lead to sudden subsidence of the ground surface or loss of bearing friction at piles. The verification of absence of liquifiable sands will be needed before structures are placed on site.

In designing earthquake-resistant structures at a given site, it is necessary to know the highest intensity of expectable ground motion to occur during the lifetime of the structure

In the Borderland moderate-sized earthquakes are definitely known to have occurred,but the history of large earthquakes and the time interval between recurrence is less certain. As indicated in Figure II-5 and II-5a-5F and the previous discussion of historical earthquakes, magnitudes larger than 6 are not uncommon to the Borderlands. Numerous earthquakes smaller than 6 occur yearly (Bureau of Reclamation, 1973).

While small magnitude earthquakes are much more frequent in the Borderland it is possible that an intense earthquake could occur in a fault area of only previously minor earthquakes. The White Wolf fault, which generated the 1952 Kern County earthquake (7.7 magnitude), was unrecognized as a contemporary earthquake hazard prior to the earthquake (Oakeshott, 1955).

We feel that a maximum credible earthquake magnitude for the entire proposed lease area can not be given due to the vast area involved and sketchy data, particularly on the outer banks. The maximum credible earthquake for each potential structural location could be determined on an individual and/or area basis, until active faults can be delineated in more detail.

Page (1972) indicated that peak acceleration have a strong dependence on the distance to the earthquake epicenter and on the earthquake magnitude. Figure A-13 reveals Page's findings that "peak acceleration increases with magnitude at all distances for which data exist and attenuates with distance r at a rate in the range $r^{-1.5}$ to $r^{-2.5}$." This idea is shown clearly by the 1971 San Fernando earthquake from which numerous stations recorded peak horizontal acceleration shown in Figure A-14. The stations were located at various distances (3 to 220 km) from the focus of the earthquake. Page (1972) points out that the peak horizontal acceleration of the San Fernando earthquake was 1.25 which was nearly double of any earthquake prior to 1971.

The difference between the prior 1971 peak horizontal accelerations and the San Fernando (1971) and extrapolated peak horizontal accelerations (from Page) indicates that earthquake design criteria (acceleration) might be inadequate at the present time and should be carefully assessed before being applied to future designs.

Man-Made Earthquakes

Not all of the earthquake hazard in the Borderland region is due

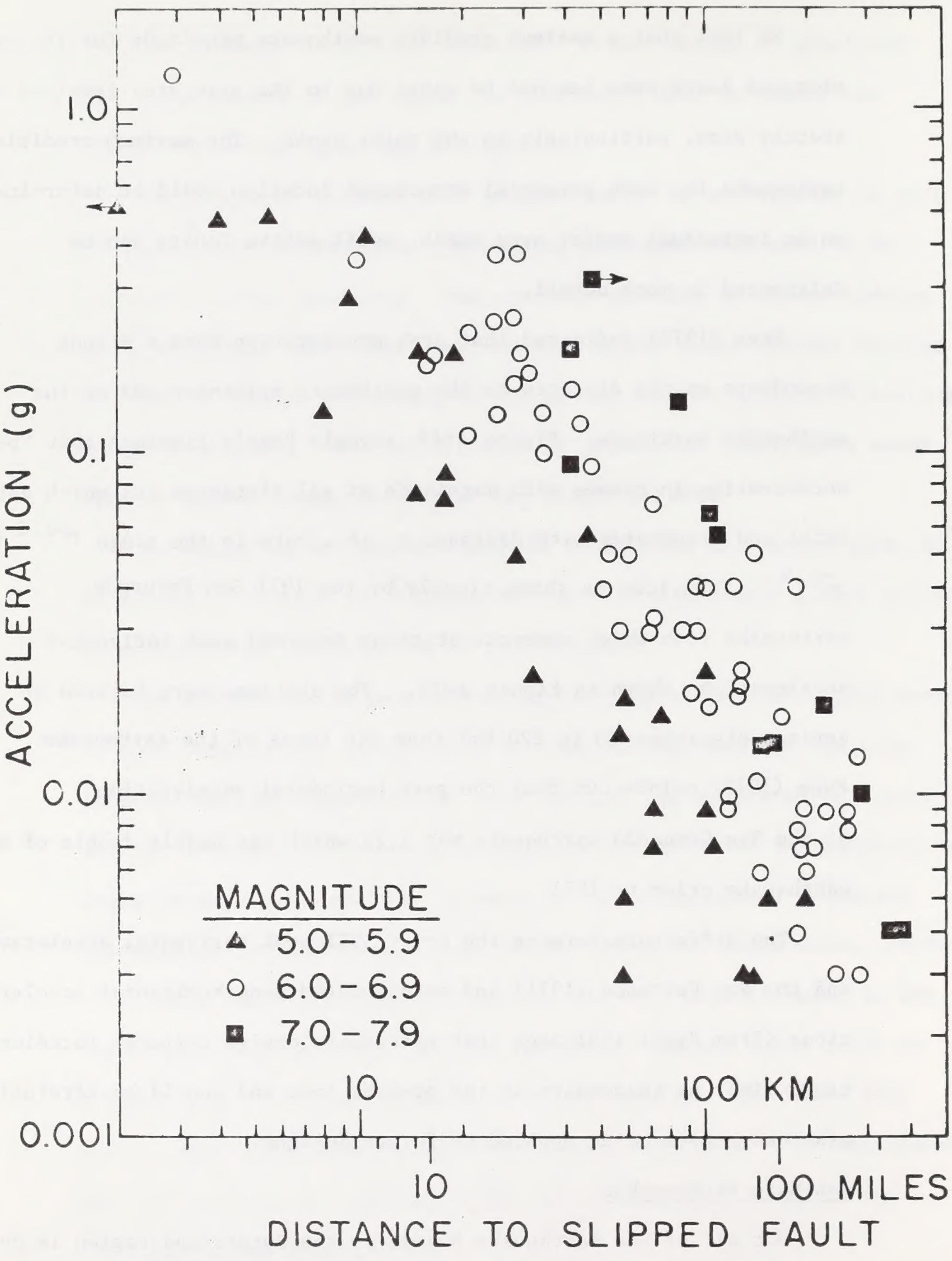


Figure A-13 Peak horizontal acceleration versus distance to slipped fault as a function of magnitude. Modified from Page and others (1972)

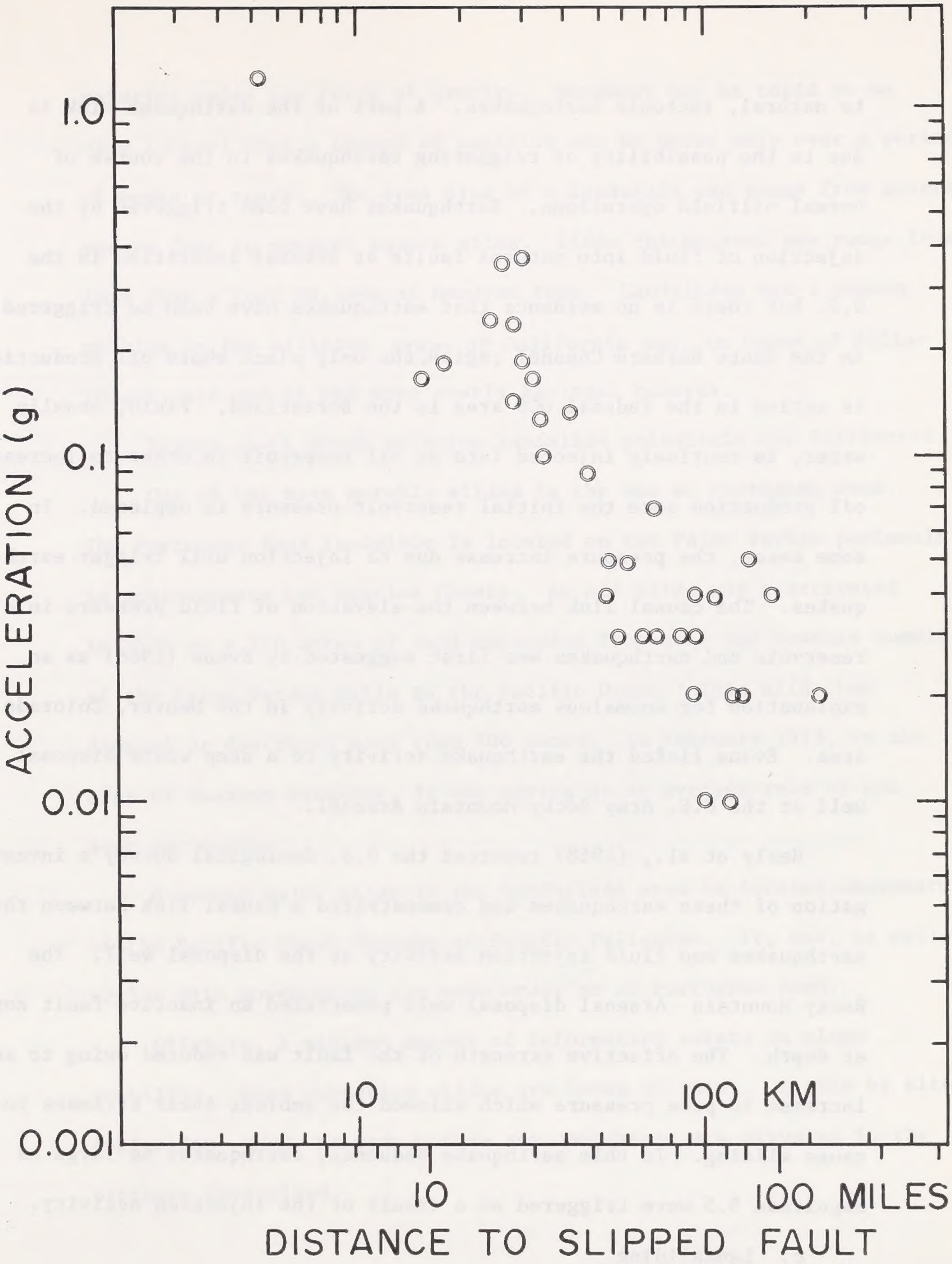


Figure A-14 Peak horizontal acceleration versus distance to slipped fault of the 1971 San Fernando earthquake (6.6 magnitude).

to natural, tectonic earthquakes. A part of the earthquake risk is due to the possibility of triggering earthquakes in the course of normal oilfield operations. Earthquakes have been triggered by the injection of fluid into natural faults at several localities in the U.S. but there is no evidence that earthquakes have been so triggered in the Santa Barbara Channel region, the only place where oil production is active in the Federal OCS area is the Borderland. Fluid, usually water, is routinely injected into an oil reservoir in order to increase oil production once the initial reservoir pressure is depleted. In some cases, the pressure increase due to injection will trigger earthquakes. The causal link between the elevation of fluid pressure in a reservoir and earthquakes was first suggested by Evans (1966) as an explanation for anomalous earthquake activity in the Denver, Colorado area. Evans linked the earthquake activity to a deep waste disposal well at the U.S. Army Rocky Mountain Arsenal.

Healy et al., (1968) reported the U.S. Geological Survey's investigation of these earthquakes and demonstrated a causal link between the earthquakes and fluid injection activity at the disposal well. The Rocky Mountain Arsenal disposal well penetrated an inactive fault zone at depth. The effective strength of the fault was reduced owing to an increase in pore pressure which allowed the ambient shear stresses to cause sliding. In this earthquake sequence, earthquakes as large as magnitude 5.5 were triggered as a result of the injection activity.

c. Landsliding

A landslide is the downhill movement of masses of earth material under the force of gravity. Movement may be rapid or so slow (creep) that a change of position can be noted only over a period of weeks or years. The area size of a landslide can range from several square feet to several square miles. Slide thicknesses may range from less than a foot to several hundred feet. Landslides are a common problem in the hillside areas of California and, in terms of dollar losses, are one of the more costly geologic hazards.

Figure A-15 shows relative landslide potentials for California.

One of the more notable slides is the one at Portugese Bend. The Portugese Bend landslide is located on the Palos Verdes peninsula in southwestern Los Angeles County. An old slide was reactivated in 1956 on a 170 acres of land extending from near the western summit of the Palos Verdes Hills to the Pacific Ocean. This slide has damaged or destroyed more than 200 homes. In February 1973, in the area of maximum movement, it was moving at an average rate of one foot per month.

A second major slide in the Borderland area is located shoreward of the Pacific Coast Highway at Pacific Palisades. It, too, is still active with movement on the same order as at Portugese Bend.

Offshore, a minimum amount of information exists on slope stability. Some submarine slides are known to exist. A site by site evaluation will be made before any operations are situated in the offshore Borderland.

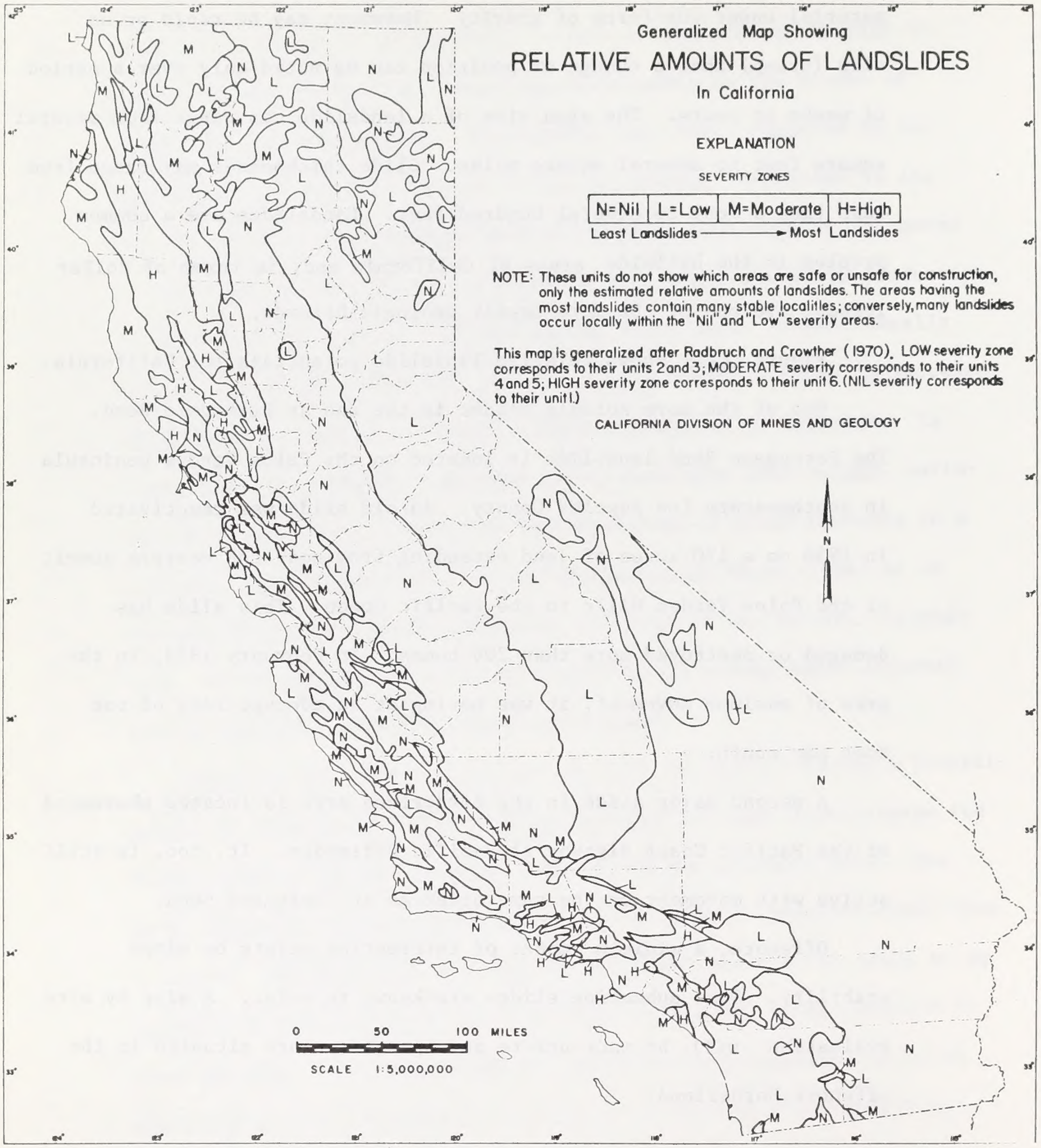

Generalized Map Showing
RELATIVE AMOUNTS OF LANDSLIDES
In California
EXPLANATION
SEVERITY ZONES
N=Nil
L=Low
M=Moderate
H=High
Least Landslides → Most Landslides
NOTE: These units do not show which areas are safe or unsafe for construction, only the estimated relative amounts of landslides. The areas having the most landslides contain many stable localities; conversely, many landslides occur locally within the "Nil" and "Low" severity areas.
This map is generalized after Radbruch and Crowther (1970). LOW severity zone corresponds to their units 2 and 3; MODERATE severity corresponds to their units 4 and 5; HIGH severity zone corresponds to their unit 6. (NIL severity corresponds to their unit l.)
CALIFORNIA DIVISION OF MINES AND GEOLOGY
N
0
50
100 MILES
SCALE 1:5,000,000

Figure A-15 Generalized map showing relative amounts of landslides in California (California Division of mines and Geology, 1973).

The potential for ocean floor slides exists mainly where the slope of the ocean floor is steep and at the mouths of submarine canyons. The USGS has purchased various types of seismic data to analyze surface and near surface conditions. Near shore these data are spaced on a half-mile grid. Slides smaller than the grid could be overlooked in analyzing the data. This potential hazard is avoided by requiring the operator of a lease to run high resolution seismic lines across any proposed site.

d. Flooding

Flooding is one of the costliest natural hazards in California. National statistics show that California ranks as one of the major flood problem areas in the nation and that flooding is one of the principal factors to be considered in the overall development and use of land resources. Although existing flood control measures have, in general, been effective in controlling or reducing flood damages, flood problems have nonetheless continued to grow. The distribution of areas subject to flooding in California is shown in Figure A-16.

The earliest recorded California flood was reported by Father Juan Crespi when a flood on the Los Angeles River caused the river to change its course in 1770. Between 1770 and 1950, 23 major floods have been recorded at various locations in the state, claiming 144 lives in the 50 years from 1900 to 1950.

In the Borderland area nine drainage basins with areas greater than 583 km^2 (225 sq. miles) drain into the Pacific Ocean, south of Point Conception. A tenth, the Santa Ynez River basin, drains a portion of the Borderland area but empties into the Pacific north of Point Conception.

The drainage basins are characterized by intermittent flow with many periods of no flow in summer and other seasons recorded. For example, the Tijuana River, the southernmost river in the area, had water in its banks only 2 days in 1971 (the last year of published records) (USGS, 1973).

During the 1969 Santa Barbara oil spill, the Los Angeles River, the Santa Clara River, the Ventura River and the Santa Ynez River had their largest recorded historic floods. Discharge reached 165,000 cubic feet per second, a volume more than 1000 times greater than

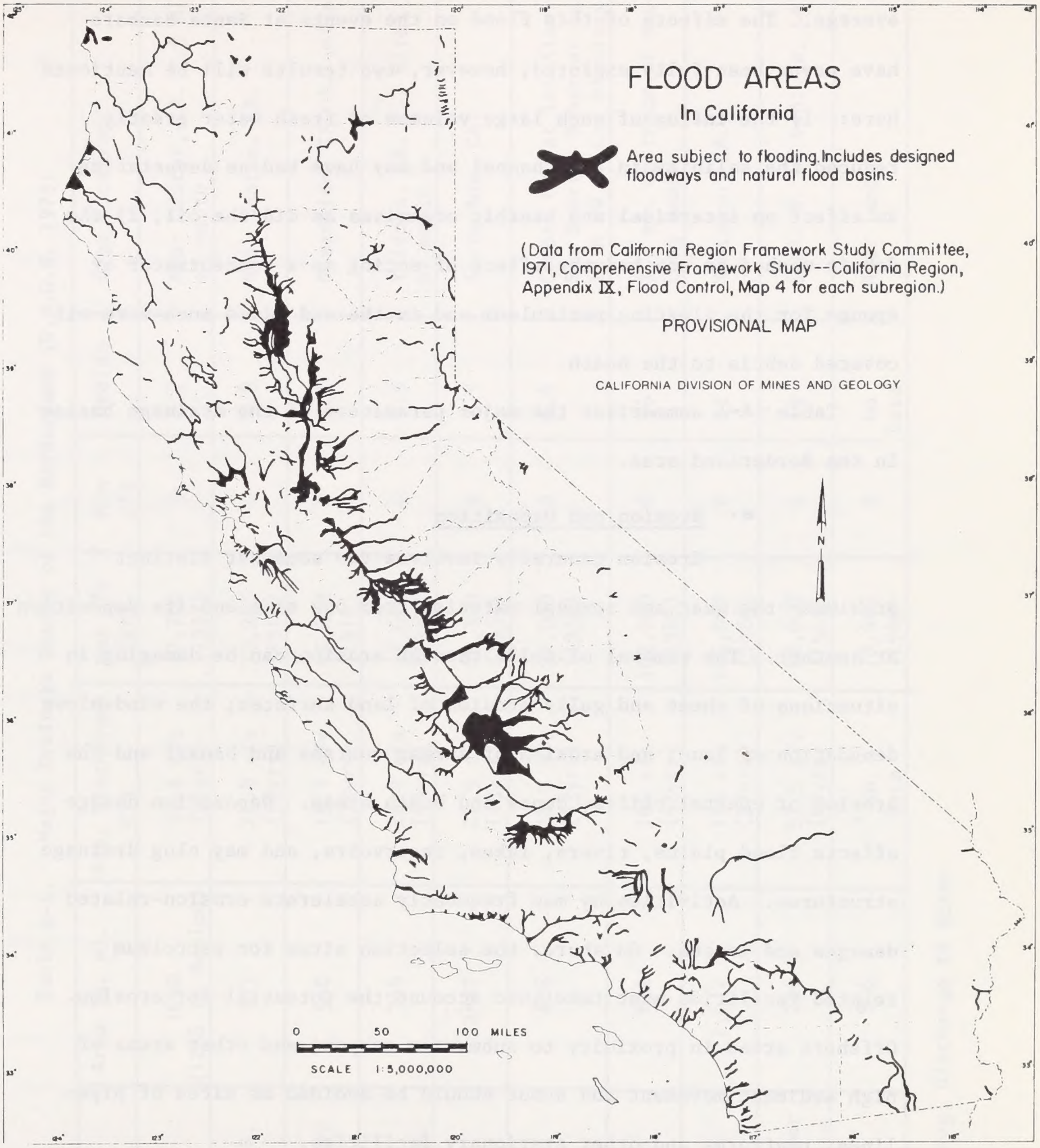

FLOOD AREAS
In California
Area subject to flooding. Includes designed floodways and natural flood basins.
(Data from California Region Framework Study Committee, 1971, Comprehensive Framework Study--California Region, Appendix IX, Flood Control, Map 4 for each subregion.)
PROVISIONAL MAP
CALIFORNIA DIVISION OF MINES AND GEOLOGY
N
0 50 100 MILES
SCALE 1:5,000,000
124° 123° 122° 121° 120° 119° 118° 117° 116° 115° 114°
42° 41° 40° 39° 38° 37° 36° 35° 34° 33°

Figure A-16 Flood area in California (California Division of Mines and Geology, 1973).

average. The effects of this flood on the events at Santa Barbara have never been fully explored, however, two results will be mentioned here: 1) the influx of such large volumes of fresh water greatly reduced the salinity in the Channel and may have had as devastating an effect on intertidal and benthic organisms as did the oil, 2) the debris washed to sea had the effect of acting as a concentrator or sponge for the floating pertroleum and in the end added much more oil covered debris to the beach.

Table A-1 summarizes the major parameters of the drainage basins in the Borderland area.

e. Erosion and Deposition

Erosion generally involves two somewhat distinct problems--the wear and removal material from one site and its deposition at another. The removal of soils through erosion can be damaging in situations of sheet and gully erosion of land surfaces; the wind-blown denudation of land; and erosion of stream courses and banks; and the erosion of coastal cliffs, dunes and beach areas. Deposition damage affects flood plains, rivers, lakes, reservoirs, and may clog drainage structures. Activities by man frequently accelerate erosion-related damages and losses. On shore, the selection sites for petroleum related facilities must take into account the potential for erosion. Offshore areas in proximity to submarine canyons and other areas of high sediment movement and scour should be avoided as sites of pipelines, platforms and other stationary facilities.

Table A-1. Major Drainage Basins of the Borderland (U.S.G.S. 1973)

Name	Area Sq. mi.	Ave. Discharge cfs	Max cfs (yr)	Min cfs	Median	Gage Location
Tijuana R.	1690 (1236 in Mexico)	31.2 cfs (36yr)	17,700 (1937)	0	2.7	Near Nestor, CA. 2.9 mi. upstrea of mouth
San Diego R.	377	22.8 cfs (58yrs)	70,200 (1916)	0	4.8	Near Santee, CA.
San Luis Rey River	560	15.1 cfs (39yrs)	95,600 (1916)	0	1.1	Oceanside, CA. 1.1 mile upstrea
Santa Margarita R.	744	28.4 cfs (48yrs)	33,600 (1927)	0	7.5	Ysidora, CA. 1.7 miles upstrea of mouth
Santa Ana River	2457	27.9 cfs (48yrs)	46,300 (1938)	0	2.9	Santa Ana, CA.
San Gabriel River	608	28.2 cfs (43yrs)	27,000 (1938)	0	4.4	Coyote Cr. at Los Alamitos and San Gabriel River at Spring St. 13 M NW of Los Alamitos
Los Angeles River	832	166 cfs (42yrs)	102,000 (1969)	0	96	3.7 mi. upstream of mouth at Long Beach
Santa Clara River	1,612	114 cfs (27yrs)	165,000 (1969)	0	22	Montalvo, CA.
Ventura River	226	57.5 cfs (44yrs)	58,000 (1969)	0	19	5 mi. N. of Ventura, CA.
Santa Ynez River	896	No Data	78,000 (1969)	0	No Data	Near Lompoc

Note (1) Avg. Discharge to Ocean

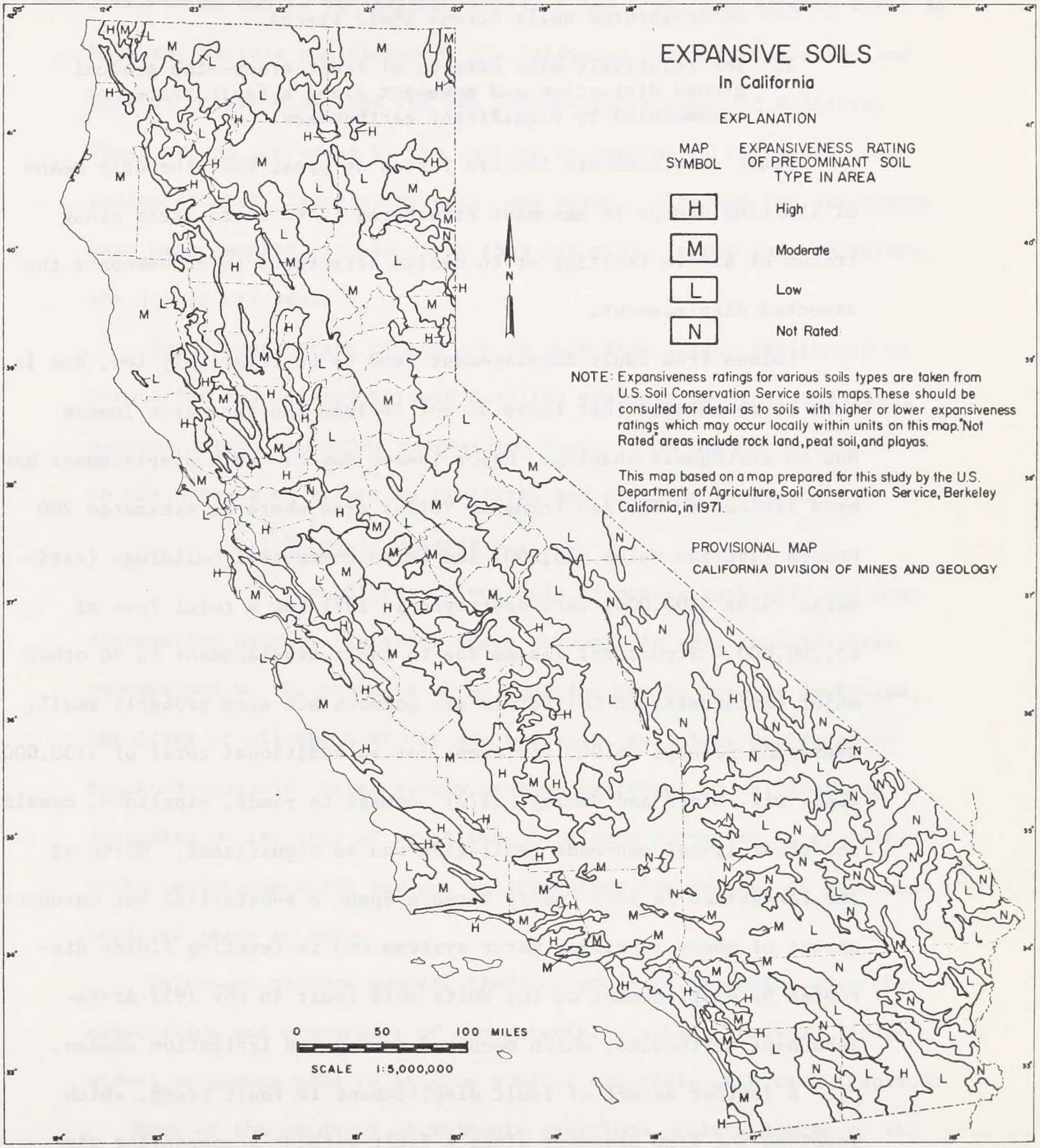
f. Expansive Soils

Expansive soils are earth materials which greatly increase in volume when they absorb water and shrink when they dry out. Expansion is most often casued by clay minerals, primarily montmorillonite and illite. Although not common, expansive rocks are also known, these are claystones or altered volcanic tuffs which contain large proportions of montmorillonite. The basic cause of expansion is the attraction and absorption of water into the expandable crystal lattices of the clay minerals. The water may be derived from moisture in the air or ground water beneath the foundations of buildings. When buildings are placed on expansive soils, foundations may rise each wet season and fall each dry season. Movements may vary under different parts of a building with the result that foundations crack, various structural portions of the building are distorted, and doors and windows are warped so that they do not function properly. The generalized distribution of expansive soils in California is shown in Figure A-17. The Southern California Coastal area is of moderate to high expansiveness.

g. Fault Displacement

Fault displacement has been discussed to a degree in the Recent Deformation subsection (II A.7.a.i.) of earthquake hazard. It is further discussed here:

A fault is a fracture in the crust of the earth along which there has been movement or displacement. Active faults are the main source of earthquakes. Petroleum operators should consider the possible future effects of fault movement in conjunction with the placement and design of new structures. Two aspects of fault displacement



NOTE: Expansiveness ratings for various soils types are taken from U.S. Soil Conservation Service soils maps. These should be consulted for detail as to soils with higher or lower expansiveness ratings which may occur locally within units on this map. "Not Rated" areas include rock land, peat soil, and playas.

This map based on a map prepared for this study by the U.S. Department of Agriculture, Soil Conservation Service, Berkeley California, in 1971.

PROVISIONAL MAP
CALIFORNIA DIVISION OF MINES AND GEOLOGY

Figure A-17. Expansive Soils in California (California Division of Mines and Geology, 1973).

should be considered:

1. The effects that sudden displacement along faults may have on structures built across their traces.
2. The relatively slow effects of fault creep--the gradual ground distortion and movement along a fault trace not accompanied by significant earthquakes.

Fault displacements involve forces so great that the only means of limiting damage to man-made structures is to avoid areas along traces of active faulting or to design structures to accommodate the expected displacement.

Losses from fault displacement tend to be relatively low, but it must be remembered that these do not include the extensive losses due to earthquake shaking. Major losses due to fault displacement have been limited to the San Fernando Valley area where an estimated 200 houses (average value $25,000) and three commercial buildings (estimated value $200,000) were destroyed in 1971 for a total loss of $5,200,000. Structural losses due to fault displacement in 26 other major earthquakes in California are unknown but were probably small, averaging perhaps $5,000 per event for an additional total of $130,000. (Cal. Div. Mines and Geolog., 1973) Damage to roads, pipelines, canals, and other linear man-made facilities can be significant. North of the Borderland in Kern County farmers spent a substantial but unreported amount of money repairing water systems and re-leveling fields disrupted by displacement on the White Wolf fault in the 1952 Arvin-Tehachapi earthquake, which occurred during the irrigation season.

A further aspect of fault displacement is fault creep, which involves the slow movement along a fault without accompanying significant earthquakes. Damage due to fault creep has been recorded along three faults in the San Francisco Bay Area; the Hayward fault in Hayward, Berkely and Richmond; the Calaveras fault in Hollister and east of Morgan Hill; and the San Andreas fault south of Hollister. The creep is expressed by the rupture or bending of buildings, irrigation ditches, tunnels, streets, and curbs. Although the structures have been damaged, in all cases they are still in use and, therefore, the losses are small.

The present state of the art is such that active faults can be identified and located through detailed geologic mapping, drilling, seismic study, and other geophysical work. This should be done in the process of selecting platforms and pipeline locations.

h. Volcanic Hazards

The effects of volcanic eruptions rank with the most devastating natural disasters known to man. An area that has been overwhelmed by the products of an eruption may be totally destroyed, the lives of all who have not escaped lost, buildings destroyed or rendered unusable, water supply systems destroyed or polluted and depending on the type of eruptions, farmlands converted to sterile, rocky landscapes which may not be productive for decades or even hundreds of years to come.

Volcanoes produce several kinds of products depending upon the composition and properties of the material erupted. However, individual volcanoes tend to produce similar materials with each eruption.

Most of the products of volcanic eruptions produce damage by the intrinsic heat within their rocks or by covering the works of man beneath their voluminous deposits.

Although the damage caused by volcanic eruptions can be total, their recurrence is infrequent enough that man may live between eruptions with relative ease.

In the Southern California Borderland, the last volcanic activity detectable is Miocene in age. No local volcanic eruptions were recorded in the rock record for at least the last 10 million years, but some traces of ash from unknown sources have been found in Pleistocene sections.

REFERENCES

Allen, C. R., Pierre St. Amand, C. F. Richter, and J. M. Nordquist. 1965. Relationship between seismicity and geologic structure in the Southern California region. Seismol. Soc. America Bull., U. 55, p. 753-797.

Allan Hancock Foundation. 1965. An Oceanographic and biological survey of the Southern California mainland shelf. California State Water Quality Control Board, Pub. 27.

Allen, D. R., P. St. Amand, C. F. Richter, and J. M. Nordquist. 1965. Relationship between seismicity and geologic structure in the Southern California region. Bull., Seis. Soc. Am. 5(4): 753-797.

Allen, D. R. 1973. Subsidence, rebound and surface strain associated with oil producing operation, Long Beach, California. In Moran, D. E. et al., eds. Geology Seismicity and Environmental Impact. Assoc. Engr. Geol., Spec. Publ., p. 101-113.

Allen D. R., and M. N. Mayuga. 1969. The mechanics of compaction and rebound, Wilmington Oil Field, Long Beach, California. In Land Subsidence 2(89): 410-423, LASH-UNESCO-WMO.

Artim, H. R., and C. J. Pinckney. 1973. La Macion fault system. San Diego, California, Geol. Soc. America Bull., v. 84, No. 3, p. 1875-1080.

Bailey, E. H. 1941. Mineralogy, petrology and geology of Santa Catalina Island. California, Ph.D. dissertation, Stanford Univ.

Barnes, B. B. 1970. Marine phosphorite deposit delineation techniques tested on the Coronado Bank, Southern California: Offshore Technology Conference, 1970, Paper No. 1259, p. 315-342.

Barnes, Peter W. 1970. Marine geology and oceanography of Santa Cruz basin off Southern California. Unpublished Ph.D. dissertation, USC, 175 p.

Bureau of Reclamation. 1973. California undersea aqueduct reconnaissance investigation. Appendix C., Earthquake Epicenter Listing.

Byerly, Perrty. 1930. The California earthquake of November 4, 1927. Seismol Soc. America Bull., v. 20, No. 2, p. 53-66.

California Division of Oil and Gas. 1961. California oil and gas field maps and data sheets--part 2, Los Angeles-Ventura basins and Central Coast Ranges. San Francisco, California Div. Oil and Gas, p. 495-913.

California Division of Mines & Geology. April 1972. California geology.

California Div. of Mines & Geology. 1973. Urban geology, master plan for California. Sacramento, California, California Division of Mines and Geology.

Cronan, D. S. 1972. Regional geochemistry of ferromanganese nodules in the world ocean. In Horn, D. R. ed. Papers from a conference on Ferromanganese deposits on the ocean floor (Arden House, Harrinan, New York and Lamont-Doherty Geol. Observatory, Columbia Univ., Palisades, N.Y., January 20, 21, 22, 1972): Washington, D.C., National Science Foundation, p. 19-30.

Curran, J. F., B. Hall and Robert Herron. 1971. Geology, oil field, and future petroleum potential of Santa Barbara Channel Area, California. In Cram, I. H., ed. Future petroleum provinces of the United States: Their geology and potential, Am. Assoc. Petr. Geol., p. 192-211.

Dibblee, T. W., Jr. 1950. Geology of southwestern Santa Barbara County, California: Point Arguello, Lompoc, Point Conception, Los Olivos, and Gaviota quadrangles: California Div. of Mines Bull. 150, 95 p.

Dietz, R. S., K. O. Emery, and F. P. Shepard. 1942. Phosphorite deposits on the seafloor off Southern California. Geol. Soc. American Bull., v. 53, p. 815-848.

Duncan, D. C., and V. E. Swanson. 1965. Organic-rich shale of the United States and World: U.S. Geol. Survey Circ. 523, 30 p.

Eaton, G. P. 1958. Miocene volcanic activity in the Los Angeles basin. In a guide to the geology and oil fields of the Los Angeles and Ventura regions. Am. Assoc. Petr. Geol., Pac. Sec., p. 55-58.

Emery, K. O. 1960. The sea off Southern California: A modern habitat of petroleum. N.Y., John Wiley & Sons, 366 p.

Evans, D. 1966. The Denver area earthquakes and the Rocky Mountain Aresnal well: Mt. Geologist, v. 3, p. 23-26.

Fischer, P. J. and A. J. Stevenson. 1973. Natural hvdrocarbon seeps along the northern shelf of the Santa Barbara basin, California. Offshore Technology Conference. OTC 1738.

Goodyear, W. A. 1888. Santa Barbara County, in petroleum, asphaltum, and natural gas: California Mining Bur., 7th Ann. Rept. State Mineralogist, p. 89-91.

Healy, J. H., W. W. Rubey, D. T. Griggs, and C. B. Raleight. 1968. The Denver earthquakes: Science, v. 161, No. 3848, p. 1301-1310. .

Heizer, R. F. 1943. Aboriginal use of bitumen by the California Indians. California Div. Mines Bull. 118, p. 74.

Inderbitzen, A. L., A. J. Carsola and D. L. Everhart. 1970. The submarine phosphate deposits off Southern California. 1970 Offshore Tech. Conf. 2:287-304.

Jennings, D. W. 1962. Geologic map of California, Long Beach sheet (1:250,000). Calif. Div. Mines & Geol.

Jennings, D. W., and R. G. Strand. 1969. Geologic map of California, Los Angeles sheet (1:250,000). Calif. Div. Mines & Geol.

Kennedy, M. P., and G. W. Moore. 1971. Stratigraphic relationships of upper Cretaceous and Eocene formations, San Diego coastal area, California. Am. Assoc. Petr. Geol. Bull. 55:708-722.

Kennett, W. E. 1952. Channel Island columnar sections. In L. E. Redwinde, chm., et al., Cenozoic correlations...: Pacific Sec. Am. Assoc. Petroleum Geologists Geol. Names and Correlations Comm., Subcomm. on Cenozoic, 1 sheet.

Hileman, J. A., C. R. Allen and J. M. Nordquist. 1973. Seismicity of the Southern California region 1 January 1932-31 December 1972, Seismological Laboratory, Calif. Inst. of Technology.

Lee, W. H. K., and J. G. Vedder. 1973. Recent earthquake activity in the Santa Barbara Channel region (California). Seismol. Soc. America Bull., v. 63, No. 5, p. 1757-1773.

Lian, H. M. 1954. Geology of the Carpinteria district, Santa Barbara County. In R. H. Jahns, ed. Geology of Southern California: California Div. Mines Bull. 170, Map Sheet 25, scale 1 inch to 1 mile.

Marine Advisers, Inc. 1965. Examination of tsunamis potential at San Onofre nuclear generating station: unpublished report submitted to So. Calif. Edison Co.

Manheim, F. T. 1965. Manganese-iron accumulations in the shallow marine environment: Occasional Publ. 3, Narragansett Marine Laboratory, Univ. of Rhode Island, p. 217-276.

McKelvey, et al., 1968. Potential mineral resources of the United States OCS: in Public Land Law Review Commission Report, October, Appendix 5-A.

Merifield, P. M., D. L. Lamar and M. L. Stout. 1971. Geology of central San Clemente Island, California. Geol. Soc. Am. Bull. 82(7):1989-1994.

Moore, D. G. 1954. Submarine geology of San Pedro Shelf. J. Sed. Petr. v. 24, p. 162-181.

Mero, J. L. 1967. Ocean mining--a potential major new industry: Proceedings First World Dredging Conf., New York, May 6-8, 1967. P. 625-641.

Newman, G. H. 1972. "Pore-volume compressibility of consolidated, friable, and unconsolidated reservoir rocks under hydrostatic loading: Jour. Pet. Tech., Vol. 25, Feb. 1973, p.129-134.

Nunn, Herbert. 1925. Municipal problems of Santa Barbara: Seismol. Soc. America Bull. v. 15, No. 4, p. 308-319.

Oakeshott, G.B. 1955. The Kern County earthquakes in California's geologic history. In pt. 1 of Earthquakes in Kern County, California, during 1952: Calif. Div. Mines Geol. Bull. 171, p. 15-22.

Oil and Gas Journal. Feb. 15, 1971. "Oil escapes heavy damage in California quake" Oil and Gas Journal, v. 69, No. 7., p. 44.

Olmsted. F.H. 1958. Geologic reconnaissance of San Clemente Island, California. U.S. Geol. Surv. Bull. 1071-B:55-68.

Page, B.M., J.G. Marks and G.W. Walker. 1951. Stratigraphy and structure of the mountains northeast of Santa Barbara, California. Am. Assoc. Petroleum Geologists Bull., v. 35, No. 8, p. 1727-1780.

Page, R.A., D.M. Boore, W.B. Joyner and H.W. Coulter. 1972. Ground-motion values for use in the seismic design of the trans-Alaska pipeline system: U.S. Geol. Survey Circ. 672, we p.

Parker, F.S. 1971. Petroleum potential of Southern California offshore. In Cram, I.H., ed. Future petroleum provinces of the United States: Their geology and potential. Am. Assoc. Petr. Geol. p. 178-191.

Pasho, D.W. 1972. Character and origin of marine phosphorites: Univ. of Southern Calif. Dept. of Geological Sciences Report USC-GEOL 72-5, 144 p.

Richter, C.F. 1958. Elementary seismology: San Francisco, W.H. Freeman and Co., 678 p.

Rodolfo, K.S. 1964. Suspended sediment in Southern California waters. Unpublished masters thesis, USC, 91 p.

Rogers, T.H. 1965. Geologic map of California, Santa Ana sheet (scale 1:250,000). Calif. Div. Mines & Geol.

Sawabini, C.T., G.V. Chilingar, and D.R. Allen. 1972. "Triaxial compaction of unconsolidated oil sands," presented to: Soc. Pet. Eng., of AIME, San Antonio, Texas, Oct. 1972.

Scholl, D.W. 1960. Relationship of the insular shelf sediments to the sedimentary environments and geology of Anacapa Island, California: Jour. Sed. Petrology, v. 30, no. 1, p. 133-139.

Shepard, F.P. 1963. Submarine Geology: Harper and Row, New York, 348 p.

Sliter, William V. 1968. Upper Cretaceous Foraminifera from Southern California and northwestern Baja California, Mexico: Kansas Univ. Paleoat. Contr. (49), Protozoa, art. 7, 141 p., illus. tables.

Sorensen, P.E., and W.J. Mead. 1969. A new economic appraisal of marine phosphorite deposits off the California coast: Trans. Fifth Ann. Marine Technology Conference on "The Decade Ahead 1970-1980," Miami, Florida, June 15-18, p. 491-500.

State Lands Commission. 1974. Development of South Ellwood offshore oil field: Environmental Impact Analysis, Phase I, State Lands Division.

Strand, R.G. 1962. Geologic map of California, San Diego-El Centro sheet (scale 1:250,000). Calif. Div. Mines & Geol.

Takahaski, S.K., and W.E. Schneite. 1973. Preliminary investigation of structural damage from Point Mugu California earthquake of February 21, 1973: Port Hueneme, Naval Civil Eng. Lab. Tech. Note N1307.

Teng, Ta-Liang and Thomas L. Henyey. 1974. Microearthquake monitoring in the City of Long Beach are for the year 1973.

Terry, R.D., S.A. Keesling and E. Uchupi. 1956. Submarine geology of Santa Monica Bay, Calif: report to Hyperion Engineers, Inc., from Geology Dept., Univ. of Southern California, Los Angeles, 177 p.

Terry, R.D. and R. E. Stevenson. 1957. Microrelief of the Santa Monica Shelf, Calif: Geol. Soc. Amer. Bull., v. 68, p. 125-128.

Townley, S.D. and M.W. Allen. 1939. Descriptive catalogue of earthquakes of the Pacific Coast of the United States, 1769 to 1928: Seismol. Soc. America Bull., v. 29, no. 1, p. 1-297.

Turner, D.L. 1970. Potassium-argon dating of Pacific Coast Miocene foraminiferal stages. In: Bandy, O.L. (ed.) Radiometric Dating and Paleontologic Zonation. Geol. Soc. Am. Spec. paper 127, p. 91-129.

U.S. Geological Survey. 1971. The San Fernando, California, earthquake of February 9, 1971: U.S. Geol. Survey of Prof. Paper 733, 254 p.

U.S. Geological Survey. 1974. Finald environmental statement on proposed plan of development of the Sant Ynez Unit, Outer Continental Shelf, Santa Barbara Channel, off California.

Van der Knapp, W. and A. C. Van der Vlis. 1967. "On the cause of subsisdence in oil-producing areas," Proc. 7th World Pet. Cong., Mexico City, 1967, Vol. 3: Elsevier Publ. Co., The Hague, p.85-95.

Vedder, J. G. and R. M. Norris. 1963. Geology of San Nicolas Island, California. U.S. Geol. Surv. Prof. Paper 369. 65p.

Vedder, J. G. and R. D. Brown. 1968. Structural and stratigraphic relations along the Nacimiento fault in the southern Santa Lucia Range and San Rafael Mountains, California, in W. R. Dickinson, and Arthur Grantz, eds., Proceedings of conference on geologic problems of the San Andreas fault system: Stanford Univ. pubs. Geol. Sci., V. 11, p. 242-259.

Vedder, J. G. and R. E. Wallace. 1968. Map showing recently active breaks along the San Andreas and related faults between Cholame Valley and Tejon Pass, California: U.S. Geol. Survey open-file map, scale 1:24,000.

Vedder, J. G., H. C. Wanger and J. E. Schoellhamer. 1969. Geologic framework of the Santa Barbara Channel Region: U.S. Geol. Survey Prof. Paper 679A.

Vedder, J. G., et al. 1974. Geological inferences and mineral resource potential of the California Continental Borderland north of the Mexico-U.S. Boundary: special administrative report to the Director, January, 1974, 68 p.

Vedder, J. G., et al. 1975. Preliminary report on the geology of the continental borderland of Southern California: U.S. Geol. Survey Misc. Field Inv. Map MF 624, 34 p. pamphlet, 9 map sheets.

Wallace, R. E. 1968. Notes on stream channels offset by the San Andreas fault, southern Coast Ranges, California, in W. R. Dickinson, and Arthur Grantz, eds. Proceedings of conference on geologic problems of the San Andreas fault system: Stanford Univ. Pubs. Geol. Sci., V. 11, p. 6-21.

Weaver, D. W., et al. 1969. Geology of the northern Channel Islands. Am. Assoc. Petr. Geol.

Wood, H. O. 1955. The 1956 earthquake in California: Seismol. Soc. America Bull., V. 45, No. 1, p. 47-67.

Woodford, A. O. 1925. The San Onofre Breccia. Univ. of Calif. Publ. Geol. 15(7):159-280.

Woodford, A. O., and T. L. Bailey. 1928. Northwestern continuation of the San Onofre Breccia. Calif. Univ. Pubs., Dept. Geol. Sci. Bull. 17(5):187-191.

Yeats, R. 1968. Rifting and rafting in the Southern California borderland. In: Dickinson, W. R., and A. Grantz, (eds.) Proceedings of Conference on Geologic Problems of San Andreas Fault System. Stanford Univ. Publ. Geol. No. 11:307-322.

Yeats, R. 1968. Southern California structure, sea floor spreading, and history of the Pacific basin. Geol. Soc. Am. Bull. 79:1693-1702.

Yeats, R. 1970. Stratigraphic evidence for Catalina Schist basement north of Channel Islands, California. Geol. Soc. Am. Bull. 81(7):2147-2151.

Yerkes, R.F. and C.M. Wentworth. 1965. Structure, quaternary, history, and general geology of the Corral Canyon area, Los Angeles County, California: U.S. Geol. Survey open-file report.

Yerkes, R.F. and R.O. Castle. 1969. Surface deformation associated with oil and gas field operations in the United States. Intnat'l. Symp. Land Subsidence, UNESCO, Tokyo.

Ziony, J.I., et al. (in press). Preliminary map showing recency of faulting in coastal southern California. U.S. Geol. Surv. MF map.

Appendix 10

B. Climate

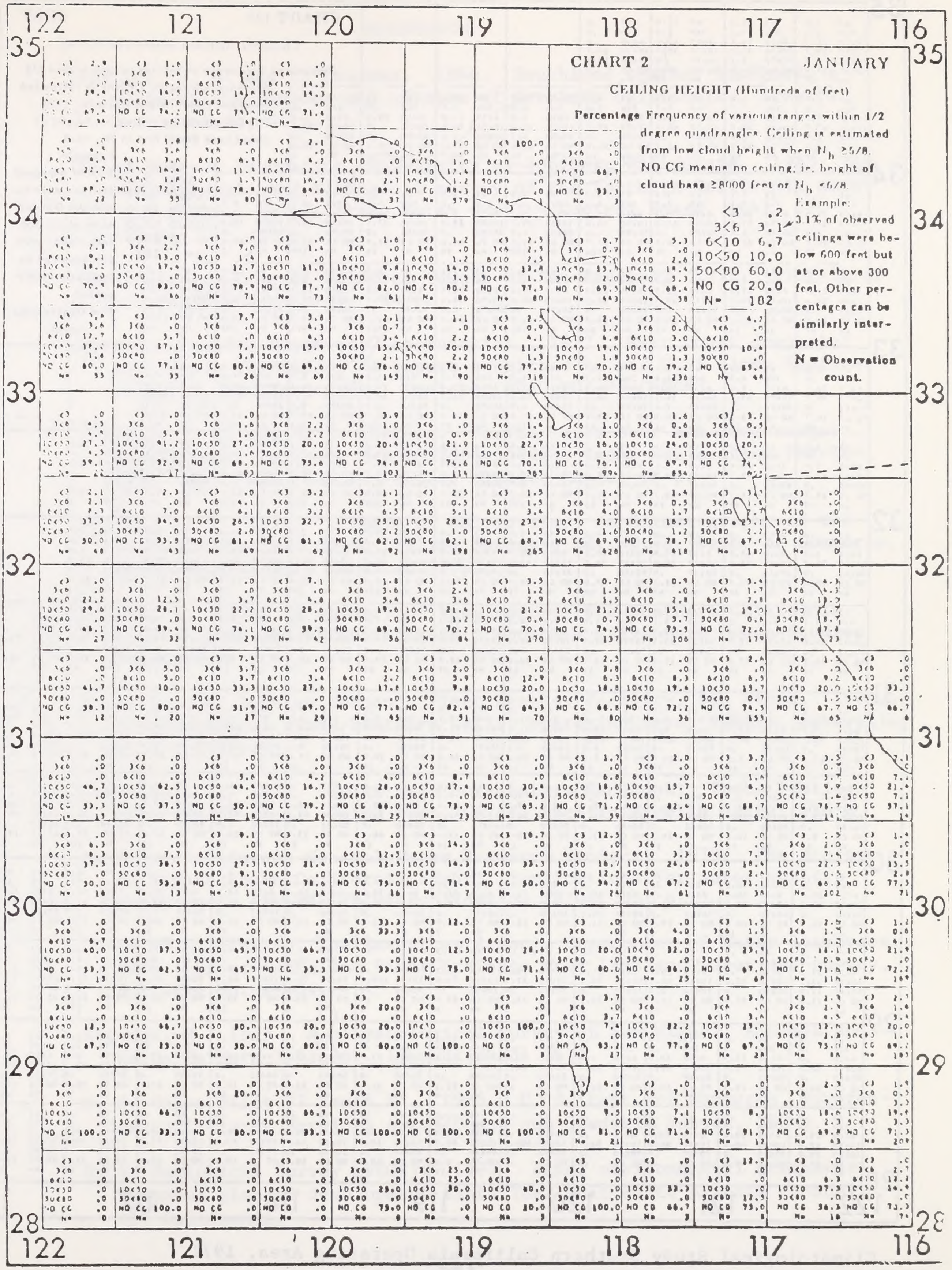


CHART 2 JANUARY

CEILING HEIGHT (Hundreds of feet)

Percentage Frequency of various ranges within 1/2 degree quadrangles. Ceiling is estimated from low cloud height when $N_h \geq 5/8$. NO CG means no ceiling; ie. height of cloud base ≥8000 feet or $N_h < 5/8$.

Example:

<3	.2
3<6	3.1
6<10	6.7
10<50	10.0
50<80	60.0
NO CG	20.0
N=	182

3.1% of observed ceilings were below 600 feet but at or above 300 feet. Other percentages can be similarly interpreted.

N = Observation count.

Climatological Study Southern California Operating Area, 1971

Table B-1

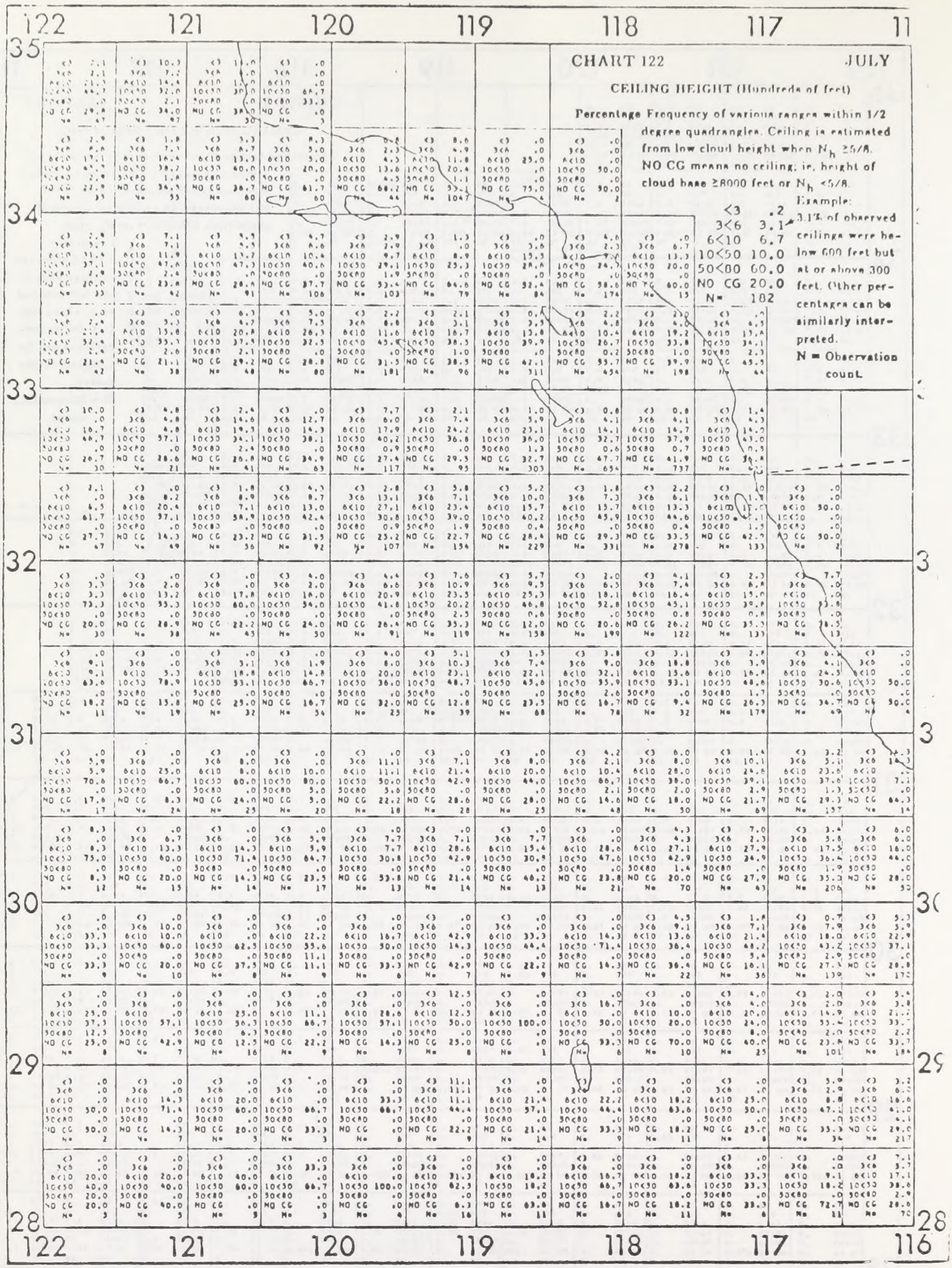


CHART 122 JULY

CEILING HEIGHT (Hundreds of feet)

Percentage Frequency of various ranges within 1/2 degree quadrangles. Ceiling is estimated from low cloud height when $N_h \geq 5/8$. NO CG means no ceiling; ie, height of cloud base ≥8000 feet or $N_h < 5/8$.

Example:

<3	.2
3<6	3.1
6<10	6.7
10<50	10.0
50<80	60.0
NO CG	20.0
N=	182

3.1% of observed ceilings were below 600 feet but at or above 300 feet. Other percentages can be similarly interpreted.

N = Observation count.

Climatological Study Southern California Operating Area, 1971

Table B-2

REFERENCES

Aldrich, J. H. and M. Meadows. 1966. Southland weather handbook, a guide to the weather and climate of Southern California. Brewster Publications, 51 p.

Allan Hancock Foundation, University of Southern California. 1965. An oceanographic and biological survey of the Southern California mainland shelf. Calif. State Water Quality Control Board, publ. 27. 232 p.

Air Pollution Control District County of Los Angeles. 1971. Profile of air pollution control. 84 p.

Battelle Pacific Northwest Laboratories. 1973. West coast deepwater port study 211B01577. A report submitted to the U. S. Army Engineer district, San Francisco. Contract #DAC W07-73-C-0063.

Edinger, J. G. and M. G. Wurtele. Marine layer over sea test range: final report contract N123(61756) 56992A, Tech. Publication PMR-TP-71-2. Pt. Mugu, Calif. Pacific Missile Range, 98 p.

Elford, C. R. 1970. Climate of California. In Climatography of the United States No. 60-4. Silver Springs, Md., U. S. Dept. of Commerce, Environmental Data Service, 57 p.

Kimura, J. 1974. A summary of knowledge of the Southern California coastal zone and offshore areas. Southern California Ocean Studies Consortium.

Naval Weather Service Command, Fleet Weather Facility, San Diego. 1971. Climotological study Southern Calif. operating area, NWSED. Asheville, N. C., 240 p.

Rosenthal, J. 1972. Point Mugu Forecasters Handbook: Tech. Publication PMR-TP-72-1. Point Mugu, Calif. Pacific Missile Range, 426 p.

Southern California Coastal Water Research Project. 1973. The ecology of the Southern California Bight: implications for water quality management. SCCWRP TR104 Publication TR104, 531 p.

State of California, The Resources Agency, Department of Water Resources. 1964. Upper Santa Ana River drainage area land and water use survey. Bulletin No. 71-64.

Strange, R. 1973. A climatological survey of San Miguel, Anacapa and Santa Barbara Islands. (Unpublished) 16 p.

U. S. Coast Pilot #7 Tenth Ed. 1968. U. S. Dept. of Commerce, Environmental Science Services Admin/Coast and Geodetic Survey, 380 p.

U. S. Geological Survey (USGS). 1974. Final environmental statement: proposed plan of development Santa Ynez Unit Santa Barbara Channel, off California.

Appendix 10

C. Physical Oceanography

1. Water Temperature

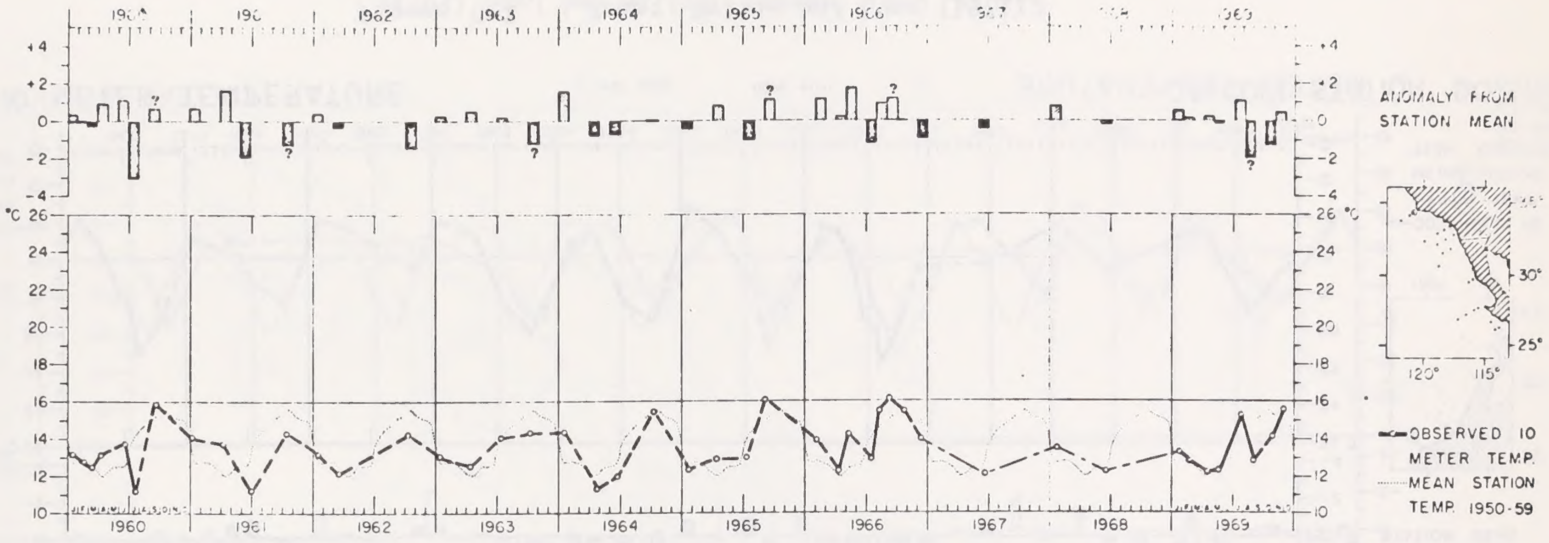
Water temperature data of 1950-1959 for this report came from California Cooperative Oceanic Fisheries Investigations (Cal COFI) (California Marine Research Committee, 1963) and were used because Cal COFI didn't average the 1960-1969 data (Wyllie and Lynn, 1971). The temperature reading of 6 representative stations during 1960-1969 are plotted against the mean 1950-1959 temperatures on Figures C-1 through C-3. There is an indication that the temperatures were slightly warmer than the ten previous years and may have been especially true to Station 90.37. Most of the differences, both above and below the 1950-1959 mean temperatures, were less than 3°C with the general seasonal trends remaining the same. Considering the broad general distribution of the ocean temperatures, there is justification in using these older temperature data.

Figures C-4 through C-7 show the mean 1950-1959 10 meter deep temperatures on quarterly basis (January, April, July, and October). During January (Fig. C-4) water temperatures vary from 12.7° to 14.65°C, with most of the area having temperatures between 13° and 15°C. During April (Fig. C-5) most readings are between 12° and 15°C. The 12° isotherm has moved south of Point Conception while the 15° isotherm has moved further north near shore. This shoreward warming is partly due to the influence of the Southern California

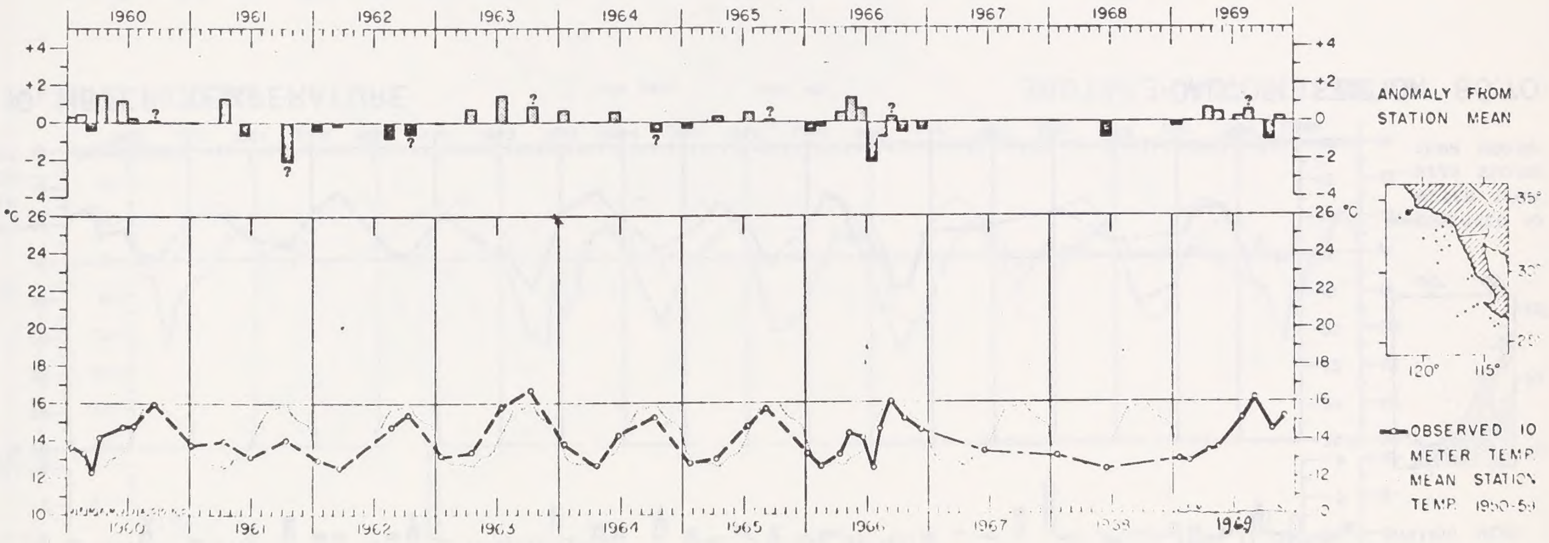
Countercurrent (Jones, 1971). During July (Fig. II-41) water temperatures are much warmer, ranging from about 14° to 19°C, and nearshore water temperatures are as much as 3°C higher than those about 200 km (125 miles) offshore. During October (Fig. C-7) water temperatures range from about 15° to 19°C. Temperatures in the northern part of the area, near Point Conception, are about 1°C warmer than they were during July. In the southern part of the area the 18° and 19°C isotherms have moved further south. At 150 meters little seasonal and horizontal temperature change occurs. Temperatures vary from 8.5° to 10°C.

2. Ocean Wind Waves (Sea and Swell)

Most waves are produced by winds and passing storms. Others are produced by geologic action such as earthquakes, volcanic activity and submarine landslides. Tidal action produces another form of wave. Waves which grow in height under the influence of the wind are referred to as wind waves or seas and the region in which they are generated is the fetch area. Once the wind waves move out of the fetch area and continue on without any additional energy input, they are referred to as swell. In Southern California, waves are predominantly from the northwest (prevailing winds) and swell may occur from any seaward direction. Wave height and direction may be the resultant of several different wave trains moving through the area.



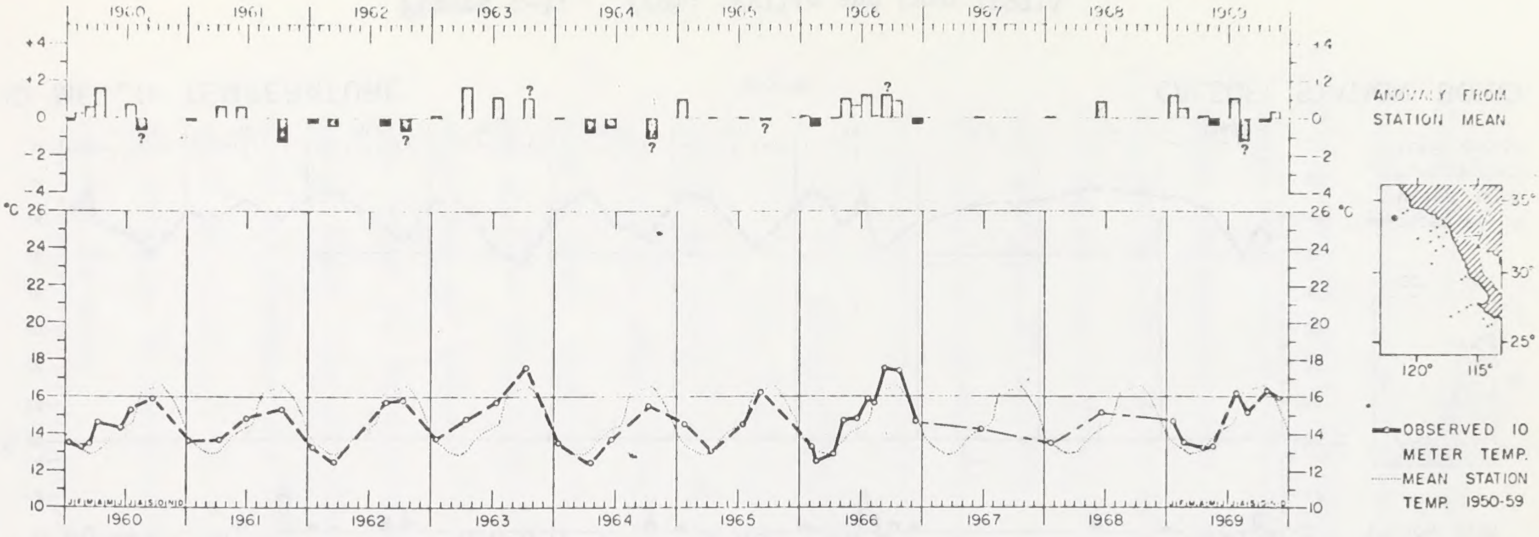
10 METER TEMPERATURE CALCOFI STATION 80.55



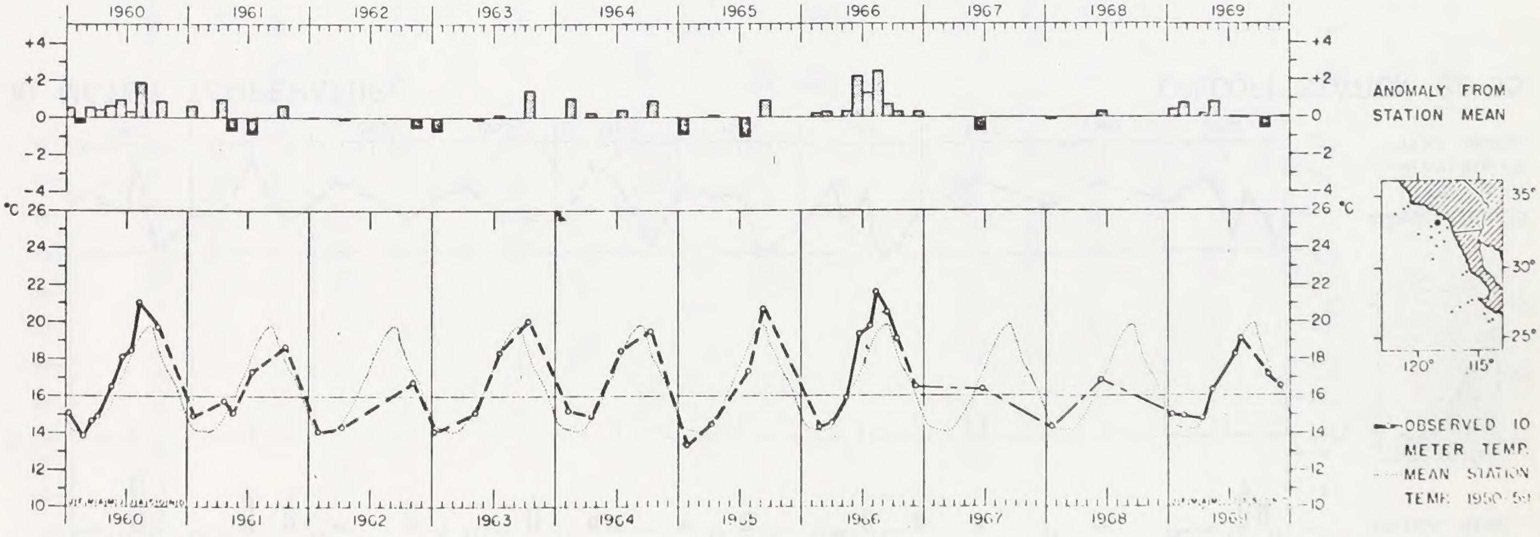
10 METER TEMPERATURE CALCOFI STATION 80.60

Figure C-1. From: Wyllie and Lynn (1971).

10m T
80.55
80.60



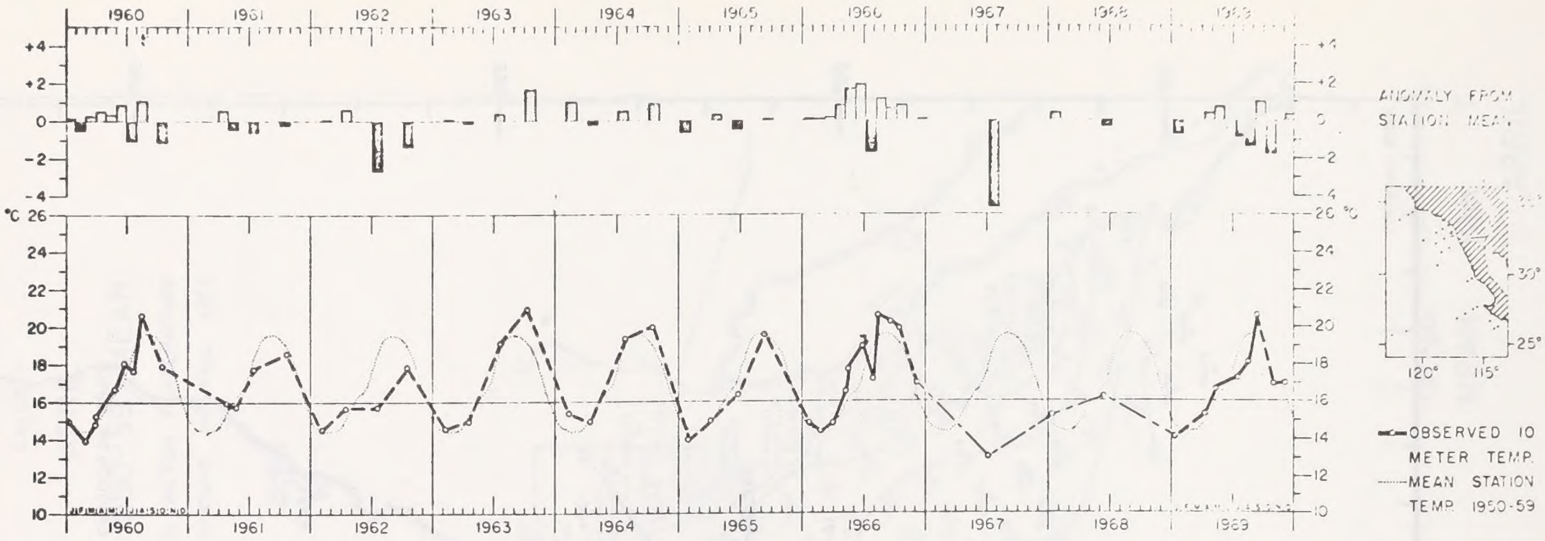
10 METER TEMPERATURE CALCOFI STATION 80.70



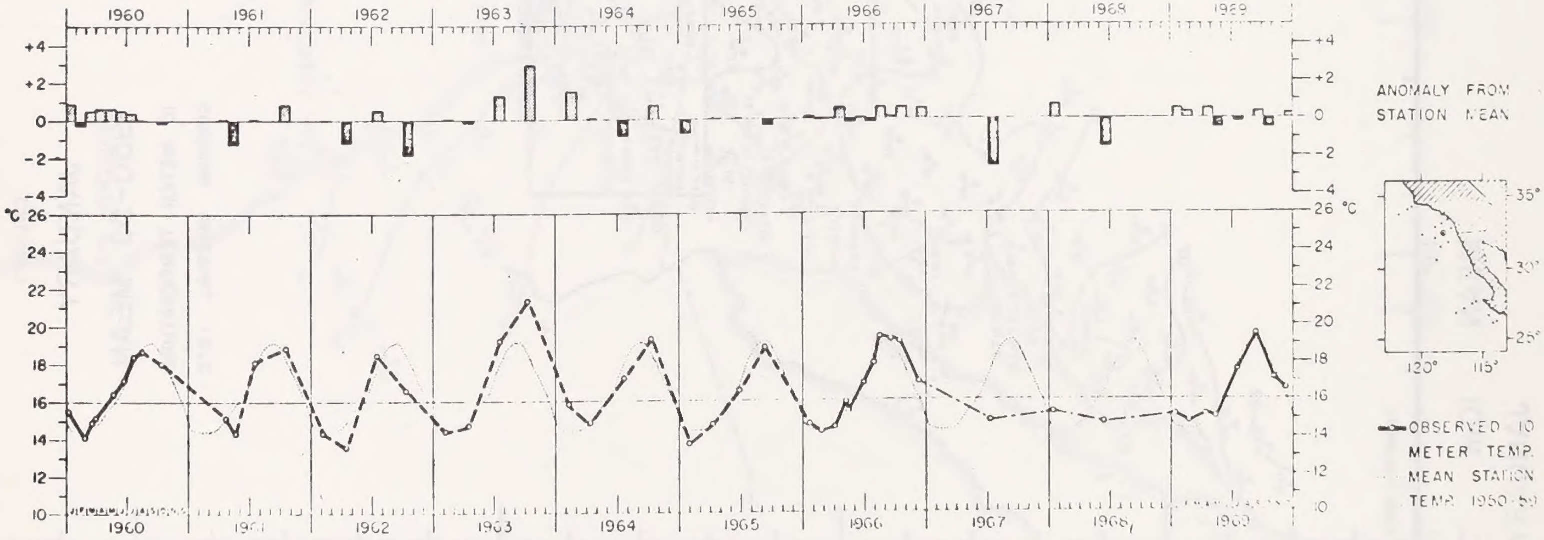
10 METER TEMPERATURE CALCOFI STATION 90.37

Figure C-2 From: Wyllie and Lynn (1971).

10m T
80.70
90.37



10 METER TEMPERATURE CALCOFI STATION 93.30



10 METER TEMPERATURE CALCOFI STATION 93.40

10m
93.30 T
93.40

Figure C-3 From: Wyllie and Lynn (1971).

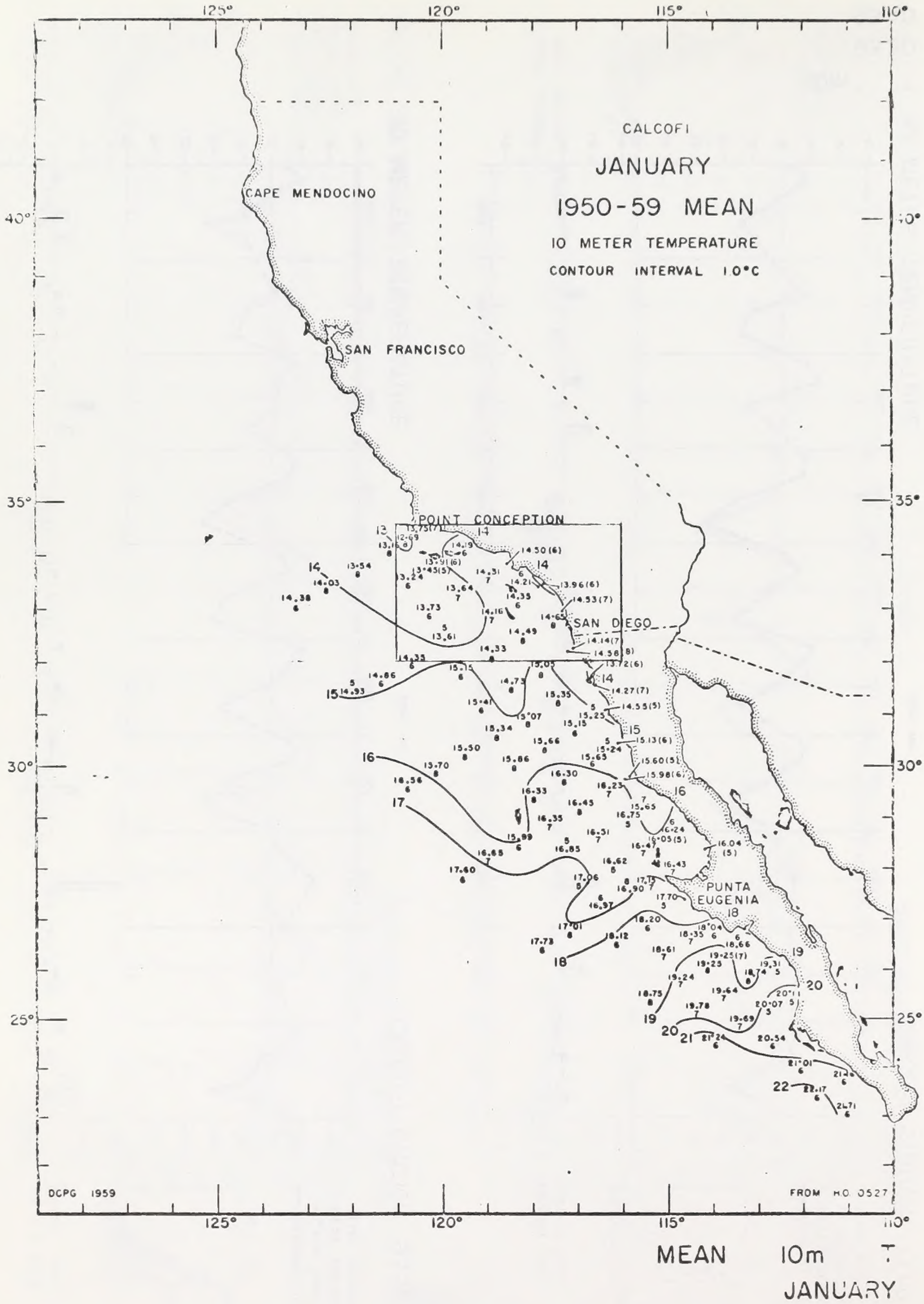


Figure C-4. From: Wyllie and Lynn (1971).

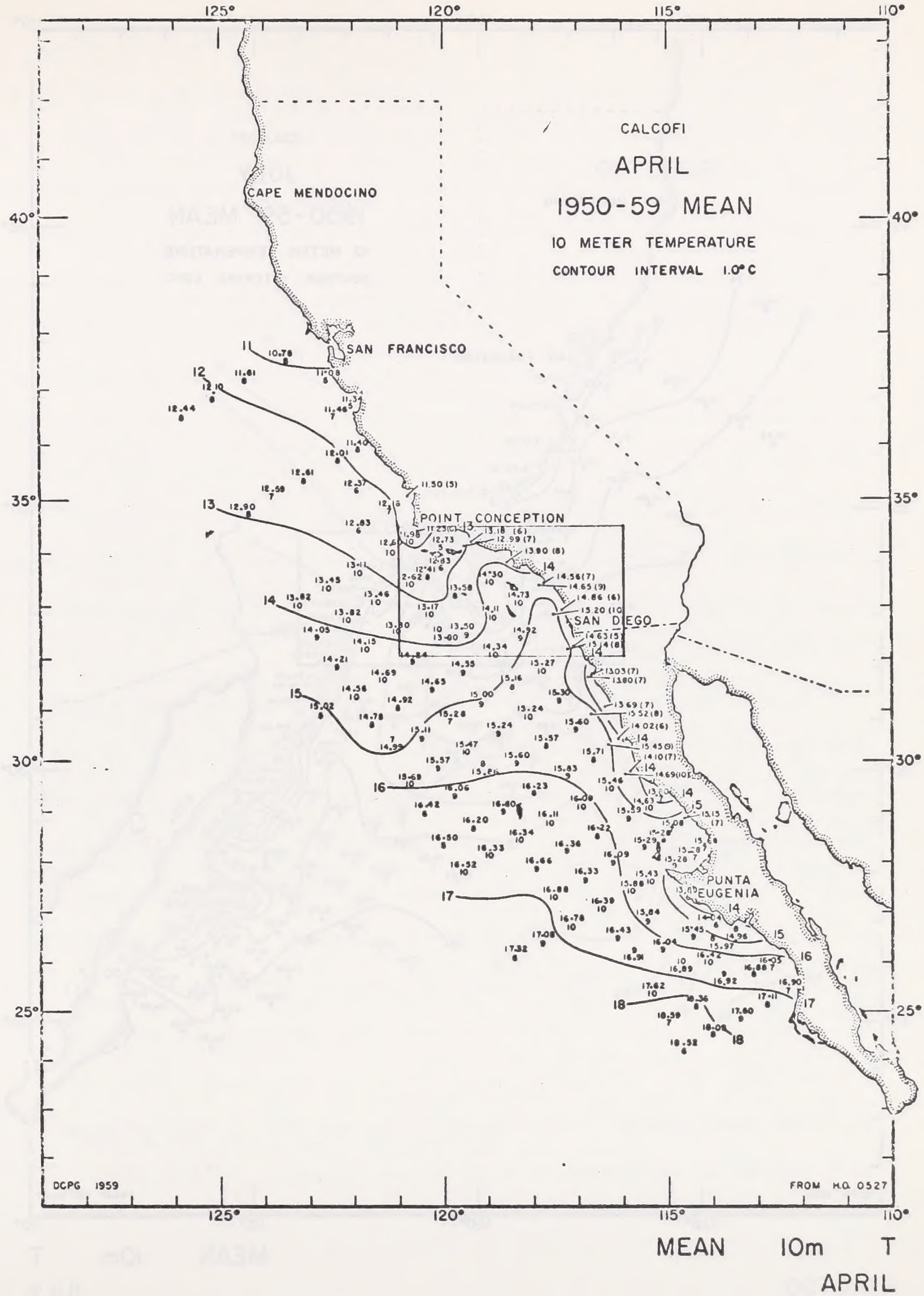


Figure C-5. From: Wyllie and Lynn (1971).

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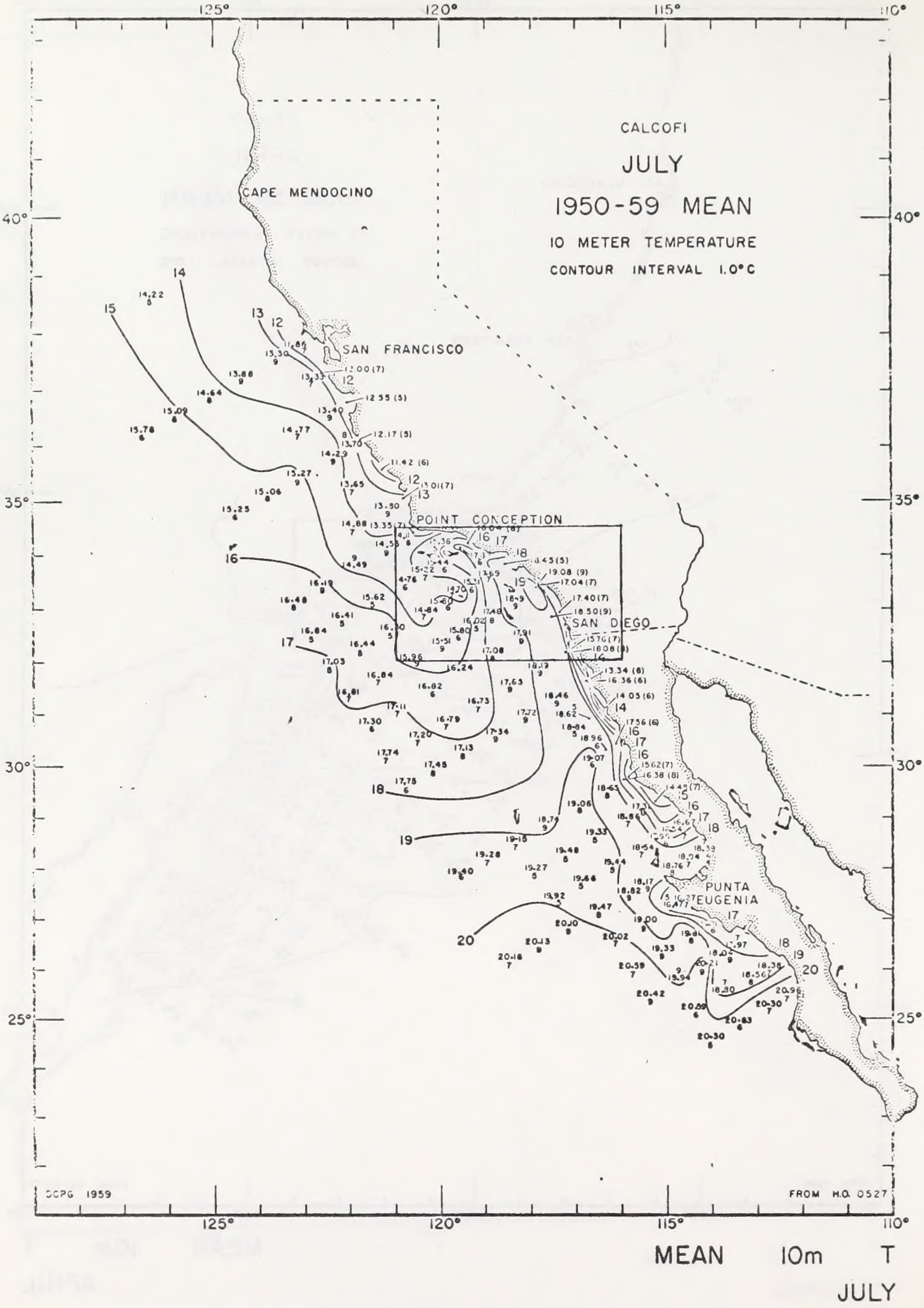
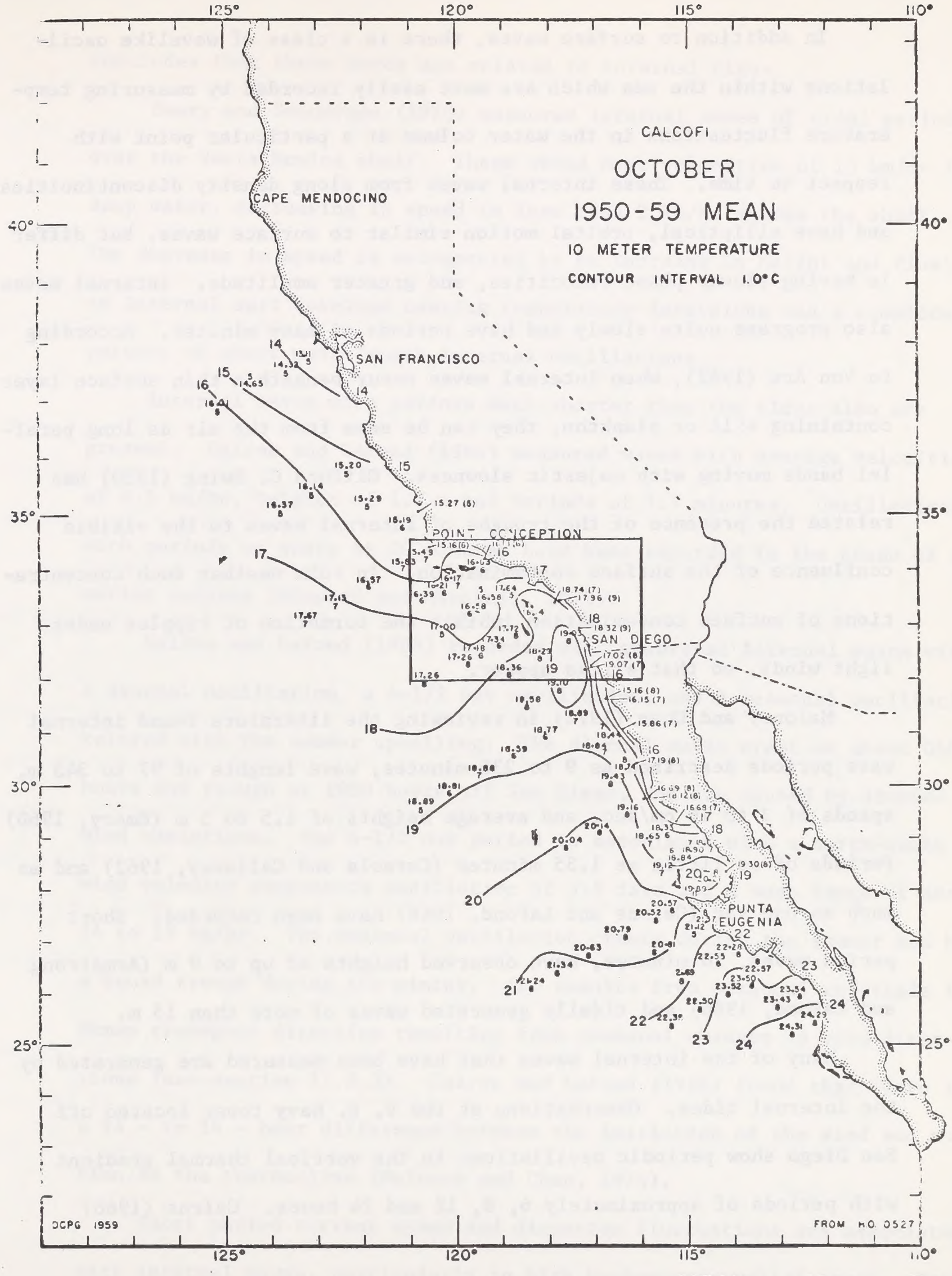


Figure C-6. From: Wyllie and Lynn (1971).



MEAN 10m T
OCTOBER

Figure C-7. From: Wyllie and Lynn (1971).

In addition to surface waves, there is a class of wavelike oscillations within the sea which are most easily recorded by measuring temperature fluctuations in the water column at a particular point with respect to time. These internal waves from along density discontinuities and have elliptical, orbital motion similar to surface waves, but differ in having slower phase velocities, and greater amplitude. Internal waves also progress quite slowly and have periods of many minutes. According to Von Arx (1962), when internal waves occur beneath a thin surface layer containing silt or plankton, they can be seen from the air as long parallel bands moving with majestic slowness. Gifford C. Ewing (1950) has related the presence of the troughs of internal waves to the visible confluence of the surface contamination. In calm weather such concentrations of surface contamination inhibit the formation of ripples under light winds, so that slicks appear.

Maloney and Chan (1974) in reviewing the literature found internal wave periods described as 9 to 236 minutes, wave lenghts of 97 to 343 m, speeds of 3 to 16 cm/sec, and average heights of 1.5 to 5 m (Emery, 1960) Periods of as little as 1.35 minutes (Carsola and Callaway, 1962) and as much as one yar (Cairns and LaFond, 1966) have been recorded. Short period waves, 10 minutes, have observed heights of up to 9 m (Armstrong and LaFond, 1966) and tidally generated waves of more than 15 m.

Many of the internal waves that have been measured are generated by the internal tides. Observations at the U. S. Navy tower located off San Diego show periodic oscillations in the vertical thermal gradient with periods of approximately 6, 8, 12 and 24 hours. Cairns (1968) concludes that these waves are related to internal tides.

Emery and Gunnerson (1970) measured internal waves of tidal periods over the Santa Monica shelf. These waves have velocities of 13 km/hr in deep water, decreasing in speed to less than 2 km/hr across the shelf. The decrease in speed is accompanied by an increase in height and finally an internal surf develops causing temperature inversions and a complicated pattern of short wave length internal oscillations.

Internal waves with periods much shorter than the tides also are present. Cairns and LaFond (1966) measured waves with average velocities of 0.5 km/hr, heights of 1.7 m and periods of 1.7 minutes. Oscillations with periods as short as 20 minutes have been recorded in the heads of submarine canyons (Shepard and Marshall, 1973).

Cairns and LaFond (1966) recorded wind generated internal waves with a diurnal oscillation, a 4-1/2 day oscillation, and a seasonal oscillation related with the summer upwelling. The diurnal waves crest at about 0600 hours and trough at 1800 hours off San Diego, and are caused by diurnal wind variations. The 4-1/2 day period is associated with a north-south wind velocity components oscillation of 3.8 days and a mean range of about 24 to 17 km/hr. The seasonal oscillation crests during the summer and has a broad trough during the winter. It results from seasonal reversals in Ekman transport direction resulting from seasonal changes in wind directions (see section II.B.3). Cairns and LaFond (1966) found that there is a 14 - to 16 - hour difference between the initiation of the wind and motion in the thermocline (Maloney and Chan, 1974).

Short period current speed and direction fluctuations are associated with internal waves, particularly in high bathymetric relief areas. They have produced currents of alternately warm and cold water on nearshore bottoms and probably are involved in surges of upwelling (SCCWRP, 1973).

The distribution and characteristics of internal waves in the Southern California Bight are important with respect to vertical mixing in the surface water and to the seasonal thermocline (Maloney and Chan, 1974). They may cause subsurface pollutants to appear at the surface and do inject random elements into field measurements.

According to the State Water Quality Control Board (1965), to some degree, nearly all of the Southern California coast is protected by the offshore islands from swell generated outside the coastal area. Certain portions are exposed to unlimited fetches from the west and south, (Figure C-8) but no location is exposed to swell from all possible seaward directions.

The best protected coastal area is from Point Conception to Ventura. Swell cannot approach this shoreline without being well modified by the Channel Islands or drastically refracted over the mainland shelf, except at Point Conception itself where swell from 220° to 250° strikes the shore with little modification. From Ventura to Port Hueneme, swell approaching from directions between 260° and 280° arrives unchanged and on occasions has caused considerable destruction along the shore.

From Port Hueneme to the Palos Verdes Hills, swell from 240° through 270° strikes the coast more or less unhindered. That portion of the coast from Point Mugu to Santa Monica is also exposed to long fetches from 180° to 200°.

In the general area from Long Beach to Newport, significant swells arrive from 260° to 280° and from 160° to 190°. From Newport south to

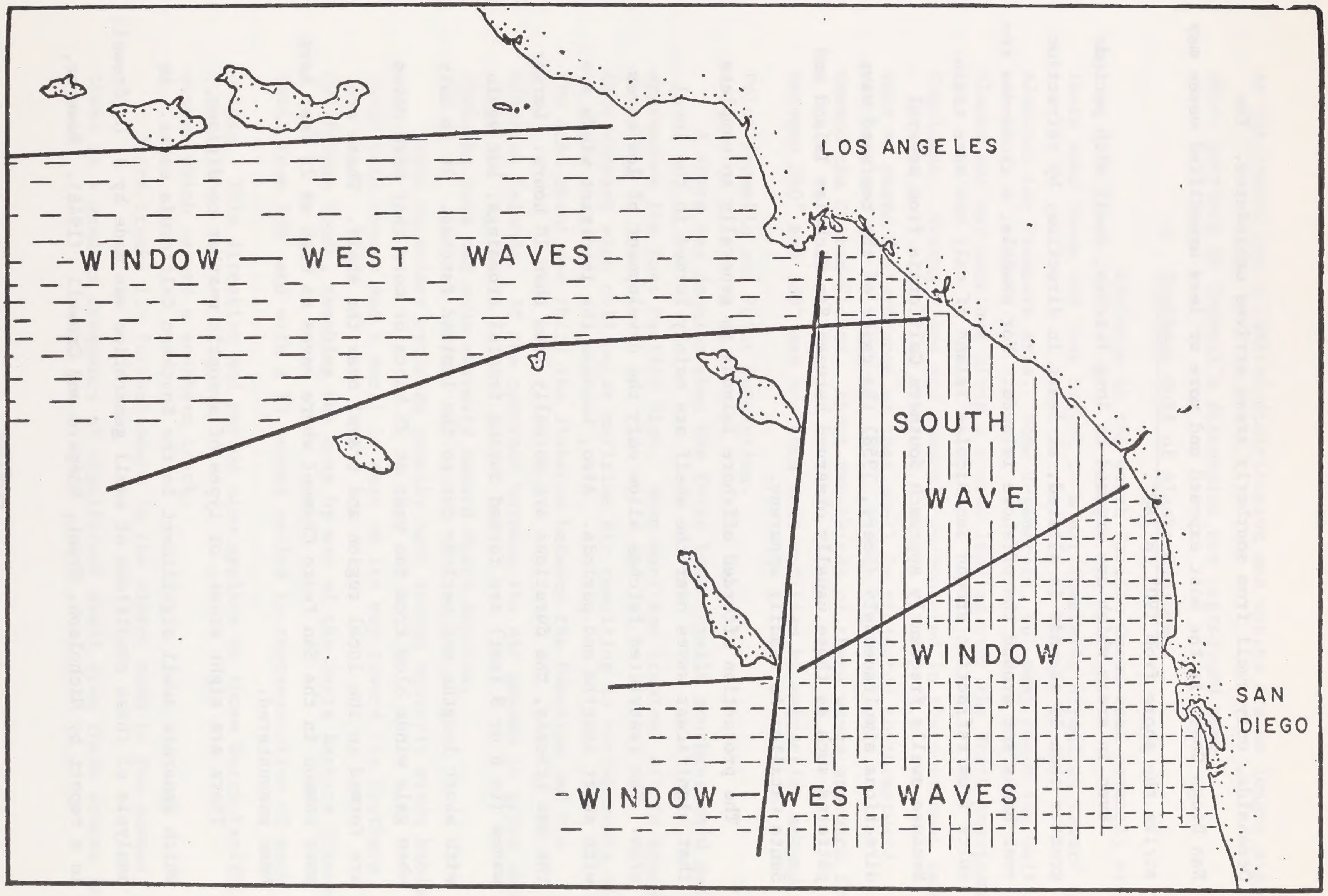


Figure C-8. Wave windows to the coast in the Southern California Bight. From: SCCWRP (1973).

Oceanside, only swell from southerly areas arrives unhindered. The San Diego Coast is the most exposed and more or less unmodified waves may strike the shore from 190° to 280°.

Even in areas which are exposed to long fetches, swell with periods greater than 10 seconds is altered, at least in direction, by refraction over banks and around the offshore islands. For example, a cross-sea results from refraction around San Nicolas Island of only one wave train. Because swells frequently approach Southern California from several directions simultaneously (Emery, 1958) the cause of the confused wave patterns such as those usually observed between San Nicholas Island and Santa Catalina is readily apparent.

The protection afforded offshore islands is generally so complete that significant waves over the shelf are mainly formed in the local area. The restricted fetches allow only the development of low waves with short lengths and periods. Also, because the important winds are the sea breezes, the durations are normally less than 10 hours. Larger waves (to 6 or 8 feet) are formed during frontal crossings, but again with short lengths and periods due to the limited fetches. It is only when gale winds blow from the west at 35 knots or more that high waves are formed in the local region and travel over the shelf. These are most common in the San Pedro Channel where waves as high as 25 feet have been encountered.

There are eight areas, or types of synoptic weather conditions, which generate swell significant to the Southern California coast. An analysis of these conditions of swell generation was made by J. C. Crowell in a report by Nicholson, Grant, Shepard and Crowell (1946). However, as the report had a limited distribution and copies are no longer available, portions of Crowell's discussion are reproduced here.

a. Southern Gulf of Alaska Cyclones

Cyclones in the north Pacific Ocean most commonly originate near Japan and then travel in a northeasterly direction toward the Aleutian Low Pressure Area. Some degenerate, but many reach the Gulf of Alaska and may continue along a course leading over the North American Continent. Strong winds are commonly encountered in the southwest sectors of these disturbances so that swell is projected southeastward toward the United States. About two-thirds of these waves approach from between 290° and 330° and are thus well modified by refraction around Point Arguello and Point Conception.

A storm may develop when the Polar Front trails southwestward and approaches the East Pacific High. Warm maritime tropical air is brought into contact with cold polar maritime air resulting in cyclogenesis in the area about one third the distance between the Hawaiian and the Aleutian Islands. If the contrast between the air masses is great enough, cyclones form and move easterly toward North America.

These secondary cyclones usually have strong westerly winds behind their cold fronts and a swell is sent on its way toward the Southern California Coast, reaching the area by way of the Santa Barbara Channel. Swell from 280° and with a 13 second period is representative of such an origin. This direction and period also applies to those North Pacific storms which assume a southern track.

Storm tracks lie further south in the winter than in the summer, so there is a greater frequency of significant swell from these storms in the winter. Even in June and July, however, conditions may be such that these generation areas are important.

Secondary cyclones from near the Hawaiian Islands may occur in families. As many as six storms may march across the ocean in sequence following similar paths. On such occasions, swell continues to arrive uninterrupted, but with variations depending on the vagaries of each storm. At other times, the secondary lows are diffuse and have complicated frontal systems. In such cases the winds are apt to be fairly weak and to range considerably in direction. Only low and moderate swell accordingly is generated.

b. North Boundary of the Pacific High

Whenever the Pacific High elongates and migrates to the south, westerly winds blowing along its north flank generate waves which arrive from between about 225° and 280°. This situation is most common in the winter. However, the wind velocities are generally less than Force 4*, so that despite long fetches and durations the swell is moderate. Waves from this source have periods of about 10 to 12 seconds and heights not exceeding three or four feet. It is estimated that these swells occur about once a month during the winter and somewhat less often in the summer.

c. Hawaiian Lows

Hawaiian Low Pressure Centers originate in the expanse of ocean two or three hundred miles north of the Hawaiian Islands. They are apt to remain stagnant for several days, or even a week, before moving slowly to the northeast. Winds within these depressions may at times dispatch swell to the California coast where it arrives with periods of 12 to 15 seconds from the west-southwest, and with moderate heights (usually less than 8 feet). Such storms occur most frequently and with the greatest strength in the spring, although examples have been known throughout the year. The approximate frequency gives an annual average of about one storm a month but with an irregular seasonal and annual distribution.

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* Beaufort Scale 13-18 mph or 11-16 knots

d. Storms in the Southern Hemisphere

Swell often arrives from a bearing between south and south-east and with long periods of from 13 to 20 seconds. These waves probably come from extratropical cyclones moving from east to west across the South Pacific Ocean between Australia and Chile. The direction of wave travel indicates either this source, or the possibility that the waves were generated by tropical storms. The latter possibility is eliminated for the longer swell because the observed period at the California coast indicates a travel distance of from 3,000 to 4,000 miles. In addition, the duration, fetches, and wind velocities in tropical storms are not great enough to develop such long periods.

This swell occurs most often in the summer when the southern winter storms are most intense and follow tracks farther to the north. These waves probably are present about two-thirds of the time, but because they are so low, the local wind waves and the more conspicuous swell from other sources mask them. Occasionally however, the presence of this type of swell in the summer may be particularly evident because the contributions from other areas are at a minimum.

e. Tropical Hurricanes

In the summer and fall, tropical storms are apt to develop off the coast of Costa Rica. Nine-tenths of these storms travel northwest from their place of origin, but dissipate long before reaching Southern California. In 55 years only one, that of September, 1939, entered Southern California waters with high winds and extensive damage. Nevertheless, some send swell toward the coast with a period of 9 to 11 seconds but the height is usually low. This swell differs from the Southern Hemisphere swell in having a shorter period. An estimate of one occurrence of heavy swell from this source every four or five years seems reasonable, but a frequency as great as once a season is possible.

f. Local Cold Front Passages

Two primary and three secondary meteorological patterns result in developing onshore wind waves. These waves are characterized by their choppiness and short period and are always accompanied by strong winds. As they are generated within the Southern California sea, the sheltering influence of the points, headlands, and islands is not too evident. Because the height and period of wind waves are functions of the wind fetch as well as velocity and duration, a variation in size and period of the waves is to be expected.

Whenever the Pacific High has weakened or moved south, and a northwesterly flow prevails over the eastern margin of the Pacific Ocean, cold fronts originating in the Southern Gulf of Alaska may move into Southern California. During the winter these storms may occur several times a month producing rain and moderate winds, first from the west and then the northwest. Before the frontal crossing, southeast winds may blow for a short period, but generally for less than a day.

The winds and fronts move in about the same direction. The fronts frequently travel at approximately the same speed as the group velocity of the waves. Only rarely do the winds and waves follow a bearing of less than 270°.

Two to four cold front passages can be expected in each of the months from December through March. In midsummer, owing to the protective influence of the Pacific High, only the strongest of these cold fronts reaches Southern California, and then with much-reduced activity.

g. Coastal Lows

Occasional depressions may form off the coast of California and move northwesterly to the continent. If the low remains for a few days southwest of Los Angeles before moving, or if it moves to the north, it may develop a swell. In either case, the period is moderate, between 8 and 10 seconds. Coastal lows may move across the area shortly after developing and before any swell has had a chance to arrive. Under these conditions wind waves are generated, but not always in an onshore direction.

h. Continental Thermal Lows

In the warmer months of the year, an extensive interior "thermal low" is situated over the southwestern United States. On occasion this low expands northwestward, especially if the East Pacific High moves northward, causing Southern California to come under the influence of the easterlies and bringing westerly winds to the coast. Usually these winds are weak and can be ignored in their influence on the waves, except as they reinforce the sea breeze.

i. Tsunamis (Seismic Sea Waves)

Tsunamis are usually generated by submarine earthquakes or volcanic eruptions. Generally they are long-period waves (from 5 minutes to several hours), low in height (a few feet or less) and may travel at speeds well over 400 knots. On the open sea in deep water, they have a low height and a tsunami will usually go unnoticed by ships at sea. Howver, as the wave moves to shallow water and breaks against the coast, a large wave may form modified by coastal and bottom configurations. Most of the damage occurs at this point, often in the form of rapidly rising water levels or bores rather than breaking waves.

According to the Coast Pilot #7 (1968), the coast of California, Oregon and Washington are not generally subject to waves of the magnitude which strike the Hawaiian Islands and other Pacific areas, although widespread damage to shipping and to waterfront areas occur occasionally. The wave of May 23, 1960, originating off the Chilean coast, caused several hundred thousand dollars damage to ships and docking facilities in the Los Angeles area alone. Much of the damage in the Los Angeles area during the 1960 wave was caused by rapid currents and the swift rise and fall of the water level which broke mooring lines and set floating docks and ships adrift.

REFERENCES

Allan Hancock Foundation. 1965. An oceanographic and biological survey of the Southern California mainland shelf. California State Resources Agency, State Water Quality Control Board Publ. 27.

Armstrong, F. A. J., and E. C. LaFond. 1966. Chemical nutrient concentration and their relationships to internal waves and turbidity off Southern California. Limnol. Oceanogr. 11: 538-547.

Cairns, J. L. 1968. Thermocline fluctuations in coastal waters. J. Geophy Res. 73(8): 2591-2595.

___________, and E. C. LaFond. 1966. Periodic motions of the seasonal thermocline along the Southern California coast. J. Geophy. Res. 71(6): 3903-3915.

CalCOFI. 1963. CalCOFI atlas of 10-meter temperatures and salinities 1949 through 1950. California Cooperative Oceanic Fisheries Investigation Atlas No. 1.

California Marine Research Committee. 1963. Cal COFI Atlas of 10-meter temperatures and salinities 1949 through 1950. California Cooperative Oceanic Fisheries Investigation Atlas No. 1.

Carsola, A. J., and E. B. Callaway. 1962. Two short-period internal wave frequency spectra in the sea off Southern California. Limnol. Oceanogr. 7: 115-120.

Emery, K. O. 1958. Shallow submerged marine terraces of Southern California. Bulletin Geological Society of America, V 69. p. 39-60.

___________. 1960. The sea off Southern California. New York, Wiley & Sons, Inc., 366 p.

___________ and G. G. Gunnerson. 1970. Internal swash and surf. Proc. Nat. Acad. Sci. 70(8): 2379-2380.

Ewing, G. 1950. J. Mar. Res. 9: 161-187.

Gaul, R. D., and H. B. Stewart, Jr. 1960. Nearshore currents off San Diego, California. J. Geophy. Res. 65: 1543-1556.

Gorsline, D. S., and D. J. Grant. 1972. Sediment textural patterns on San Pedro shelf, California. In Surft, D., et al. (eds.) Shelfs sediment transport process and pattern. Stroudsburg, Pa., Dowden, Hutchinson and Ross, p. 575-600.

Intersea Research Corporation. 1974. Review of bottom currents in the proposed Southern California offshore lease area. 26 p.

John Carollo Engineers. 1967. Ocean Outfall No. 2. Engineer's Report to County Sanitation Districts of Orange County, California.

Jones, J. H. 1971. General circulation and water characteristics in the Southern California Bight. Southern California Coastal Water Research Project. 37 p.

Kindyushev, V. I. 1970. Seasonal variations of water masses in the California region of the Pacific Ocean. Ocean. 10:458-464.

Kolpack, R. L. 1971. Oceanography of the Santa Barbara Channel. p. 90-180. In R. L. Kolpack (ed.) Biology and oceanographical survey of the Santa Barbara Channel oil spill 1969-1970. Vol. II physical, Chemical and Geological studies. Allan Hancock Found. Sea Grant Publ. No. 2, p. 90-180.

Maloney, N. J. and K. Chan. 1974. Physical oceanography. In a summary of knowledge of the Southern California coastal zone and offshore areas. The Southern California Ocean Studies Consortium. September.

Marine Advisers. 1965a. Quarterly progress report of San Onofre Oceanographic Survey. Marine Advisers for So. Cal. Edison Co., June 1965.

_______________. 1965b. Quarterly progress report of San Onofre Oceanographic Survey. Marine Advisers for So. Cal. Edison Co., September, 1965.

Nicholson, G. F., U. S. Grant IV, F. P. Shepard, and J. C. Crowell. 1946. Report on Malibu Yacht Harbor site for Malibu Quarterdeck Improvement Co. Los Angeles: typed report. 145 p.

Paquette, G. 1972. Some statistical properties of ocean currents. Ocean Engineering, Vol. 2, p. 95-114.

Pavlova, Y. V. 1966. Seasonal variation of the California Current. Oceanology 6: 806-814.

Reid, J. L., Jr. 1963. Measurements of the California Countercurrent off Baja California. J. Geophy. Res. 68: 4819-4822.

___________, and P. F. Lonsdale. 1974. On the flow of water through the Samoan Passage. Jour. Phys. Oceanog., Vol. 4, No. 1, p. 58-73.

Revelle, R. R., and F. P. Shepard. 1939. Current measurements near the sea bottom. Bull. Geolog. Soc. of Amer., Vol. 50, No. 12, p. 1929-1930 (abstract).

Southern California Coastal Water Research Project (SCCWRP). 1973. The ecology of the Southern California Bight: implications for water quality management. El Segundo, Calif. 531 p.

Schwartzlose, R. A. 1963. Nearshore currents of the western United States and Baja as measured by drift bottles. California Cooperative Oceanic Fisheries Investigations, CalCOFI, 9: 15-22.

__________________ and J. L. Reid. 1972. Nearshore circulation in the California Current. CalCOFI 16: 57-65.

Shepard, F. P., and N. F. Marshall. 1969. Currents in La Jolla and Scripps submarine canyons. Science, Vol. 165, p. 177-178.

__________________________________. 1973a. Currents along floors of submarine canyons. Bull. Amer. Assoc. Petroleum Geol., Vol. 57, No. 2, p. 244-264.

__________________________________. 1973b. Storm-generated current in La Jolla submarine canyon, California. Mar. Geol., Vol. 15, p. M19-M24.

__________________________________ and P. A. McLoughlin. 1974. Internal waves advancing along submarine canyons. Science, Vol. 183, p. 195-198.

Shepard, F. P., R. Revelle, and R. S. Dietz. 1939. Ocean-bottom currents off the California coast. Science, Vol. 89, No. 2317, p. 488-489.

Stevenson, R. E., R. B. Tibby and D. S. Gorsline. 1956. The oceanography of Santa Monica Bay, California. Allan Hancock Foundation to Hyperion Engineering.

Sverdrup, H. U. and R. H. Fleming. 1941. The waters off the coast of Southern California, March to July 1937. Bull. Scripps Inst. Oceano. 4: 261-378.

U. S. Coast Pilot #7 Tenth Edition. 1968. (ESSA. 1968) U. S. Government Printing Office.

Von Arx, W. S. 1962. An introduction to physical oceanography. Addison - Wesley Publishing Co., 422 p.

Wooster, W. S. and J. H. Jones. 1970. California Undercurrent off Northern Baja, California. J. Mar. Res. 28: 235-250.

Wyllie, J. G. and R. J. Lynn. 1971. Distribution of temperature and salinity at 10 meters, 1960-1969, and mean temperature, salinity and oxygen at 150 meters, 1950-1968, in the California Current. California Cooperative Oceanic Fisheries Investigations Atlas No. 15. 188 p.

Appendix 10

D. Chemical Oceanography

REFERENCES

Allan Hancock Foundation. 1965. An oceanogrpahic and biological survey of the Southern California mainland shelf. California State Resources Agency, State Water Quality Control Board, Publication 27.

California State Water Resources Control Board. 1963. Water quality criteria. Publication 3-A.

Chan, K. 1974. Chemical oceanography. In A summary of knowledge of the Southern California coastal and offshore areas, Vol. I. Southern California Ocean Studies Consortium.

Emery, K. O. 1960. The sea off Southern California: A modern habitat of petroleum. New York, John Wiley & Sons, 366 p.

Kindyushev, V. I. 1970. Seasonal variations of water masses in the California region of the Pacific Ocean. Ocean. 10: 458-464.

Kolpack, R. L. 1971. Biological and oceanographical survey of the Santa Barbara Channel oil spill Vol. II. Allan Hancock Foundation.

Maloney, N. J., and K. Chan. 1974. Physical oceanography. In A summary of knowledge of the Southern California coastal zone and offshore areas (Vol. I). Southern California Ocean Studies Consortium.

Rittenberg, S. C., K. O. Emery, and W. L. Orr. 1955. Regeneration of nutrients in sediments of marine basin. Deep Sea Res , 3: 23-45.

SCCWRP Report. 1973. Ecology of Southern California Bight. Los Angeles, Southern California Coastal Water Resources Project.

Sverdrup, H. U., M. W. Johnson, and R. H. Fleming. 1942. The oceans. New Jersey, Prentice-Hall, Inc.

Wyllie, J. G. and R. J. Lynn. 1971. CalCOFI Atlas No. 15. State of California Marine Research Committee.

Appendix 10

E. Biological Oceanography

1. Phytoplankton
2. Zooplankton

1. Phytoplankton

a. Methods of Sampling and Analysis

The sampling and subsequent analysis of phytoplankton in Southern California had its inception at the Scripps Institute of Oceanography. In 1971, Kofoid and Swezy started collecting dinoflagellates by towing nets of various mesh size (No. 12,20,25) through the water at a desired depth (Kofoid and Swezy, 1921). Most dinoflagellates do not retain their morphology in a preservative such as formalin so they were examined fresh immediately upon returning to the laboratory.

Between 1920 and 1940 Allen (1940) used two methods of concentrating phytoplankton. Prior to 1930 a known volume of water was filtered through a 200 mesh/inch net. This method was not adequate for retaining the nannoplankton, so after 1930 a known volume of water was allowed to stand for a day and the settled organisms were preserved and analyzed using a Sedgwick-Rafter counting cell.

More recently the Institute of Marine Resources, of the University of California, has utilized a profiling pump system which provides integrated phytoplankton samples from the surface to the desired depth (Reid et al., 1970).

Research on the techniques of estimating the standing stock has also been intensified at the Institute with investigations into the problem of preservative and slide preparation. The fixative currently in use is a 5% buffered formalin and lugol-iodine solution with ultra-violet light being used to clean the diatom, coccolith, and dinoflagellate tests from their protoplasm (University of California Institute of Marine Resources, 1970).

Estimates of phytoplankton standing stock are made by visual counting (Reid et al., 1970). The amount of cell carbon can then be determined using the expressions:

Log C (ug) = 0.76 Log V (u^3) - 0.29 for diatoms

and:

Log C (ug) - 0.94 Log V (u^3) - 0.60 for all

other phytoplanktonic organisms. Cell counts and volume estimates have also been obtained using Coulter-type electronic counters which increases the speed and precision of measurement.

The determination of plant pigments still remains the most rapid and generally used method of estimating standing stock of phytoplankton utilizing trichromatic specto-photometry (Strickland and Parsons, 1968) and fluorometry (Yentsh and Menzel, 1963). Determinations of natural populations relating chlorophyll to plant carbon has also been made (Eppley et al., 1970).

The photosynthetic fixation of carbon in a given volume of water is the most commonly measured parameter of phytoplanktonic production.

However, cell division rates averaged over a period of time give a more realistic estimate of growth than do short term productivity measurements. A method of measuring cell division rates as a function of temperature and light intensity has been developed (Jitts et al., 1964). Cell division rate relationships have been found for *Monochrysis lutheri, Amphidinium carteri, Thalassiosira nordenskioldii, Skeletonema costatum, Dunaliella tertiolecta, Fragilaria sublinearis, and Syracosphaera elongata.*

The Allan Hancock Foundation (1965) of the University of Southern California during their investigation of the Southern California mainland shelf collected water samples from the sea surface using a bucket, and from desired depths using a Nansen-type bottle. A total of 2032 samples were collected during the periods of March 1957 to December 1959 and preserved in 5% formalin solution. Laboratory analyses of the plankton samples were accomplished using the drop method described by Lackey (1938).

According to the investigators for the Southern California Coastal Water Research Project (1973), the only satisfactory method for determining the numerical abundance and species composition of phytoplankton is by microscopic examination of preserved organisms which have been centrifuged or settled from seawater samples. However, to determine the standing stock, the water sample may be filtered through membrane filters from which the chlorophyll may be extracted and measured fluorometrically.

b. Taxonomy

A series of papers published by C. A. Kofoid (1906a, 1906b, 1907, 1911a, 1911b) described several new taxa of the San Diego region. In 1921, a monograph on the unarmored dinoflagellates, which described their morphology, physiology, cytology, ecology, and taxonomy was published (Kofoid and Swezy, 1921). To date, this remains the only descriptive work on the dinoflagellates of Southern California.

Collections upon which this study was based were made off the coast primarily during the period of June to August 1906 and from June to September 1917. All samples were collected by towing a net along the surface of the water from Scripps pier at four hour intervals throughout the day and night. Besides this series of collections another series was made two to five miles offshore over depths of 100 to 600 fathoms.

A taxonomic monograph on plankton diatoms (Cupp, 1943) was prepared due to the need to solve the many species identification problems resulting from the thousands of samples that W. E. Allen collected between the years 1921 and 1945. The main emphasis of the publication was placed on planktonic diatoms off the Southern California coast but included species collected from Alaska to the Canal Zone as well. The information regarding the distribution and abundance of species encountered have been based on the collections made by Cupp (1930, 1934, 1937), Cupp & Allen (1938), Allen (1922b, 1923f, 1924b, 1927a, 1927b, 1927c, 1928a, 1928b, 1928c, 1929a, 1929b, 1930a, 1933b, 1934, 1936, 1937, 1938a, 1939), and Allen & Lewis (1927). The system of classification used was to divide the entire division into either the Centricae of Pennatae depending on the symmetry of valve decorations with the Centricae being the far more important group in the plankton. In this account 121 species were described from the Centricae and 39 from the Pennatae.

This monograph is currently the only available book dealing specifically with the phytoplanktonic flora of Southern California and is available through University Microfilms of Ann Arbor, Michigan.

c. Biochemistry

Vitamins A, B, and C have been shown to occur in algae based on chemical analyses. Most of the work, however, has been done on the B-complex vitamin. During a 6-month ecological study of coastal plankton off La Jolla, it has been shown that the concentrations of dissolved cyanocobalamin (vitamin B_{12}), thiamine (vitamin B_1) and biotin were highest when the phytoplankton standing stock was high (Carlucci, 1970). Numerous laboratory experiments have shown that many phytoplankters require and utilize vitamins for normal growth in culture (Carlucci and Silbernagel, 1969). It would therefore seem reasonable to assume that the concentrations of vitamins would be low rather than high when the standing stock is high. Laboratory experiments using pure cultures of *Skeletonema costatum, Stephanopyxis turris, Gonyaulax polyedra,* and *Coccolithus huxleyi,* four commonly occurring species off the Southern California coast, have shown that all 4 organisms excreted vitamins when provided with vitamins in the culture medium (Fig. E1-1) assumes that the same situation prevails under natural conditions, vitimans produced by healthy and lysing cells should then be released into the water. This vitamin excreting activity of the phytoplankton may be of significance in supplying vitamins for the growth of other marine organisms. It has already been established that one species of phytoplankton can utilize the vitamins produced by a different species (Carlucci and Bowes, 1970a) and that the cell contents with regard to

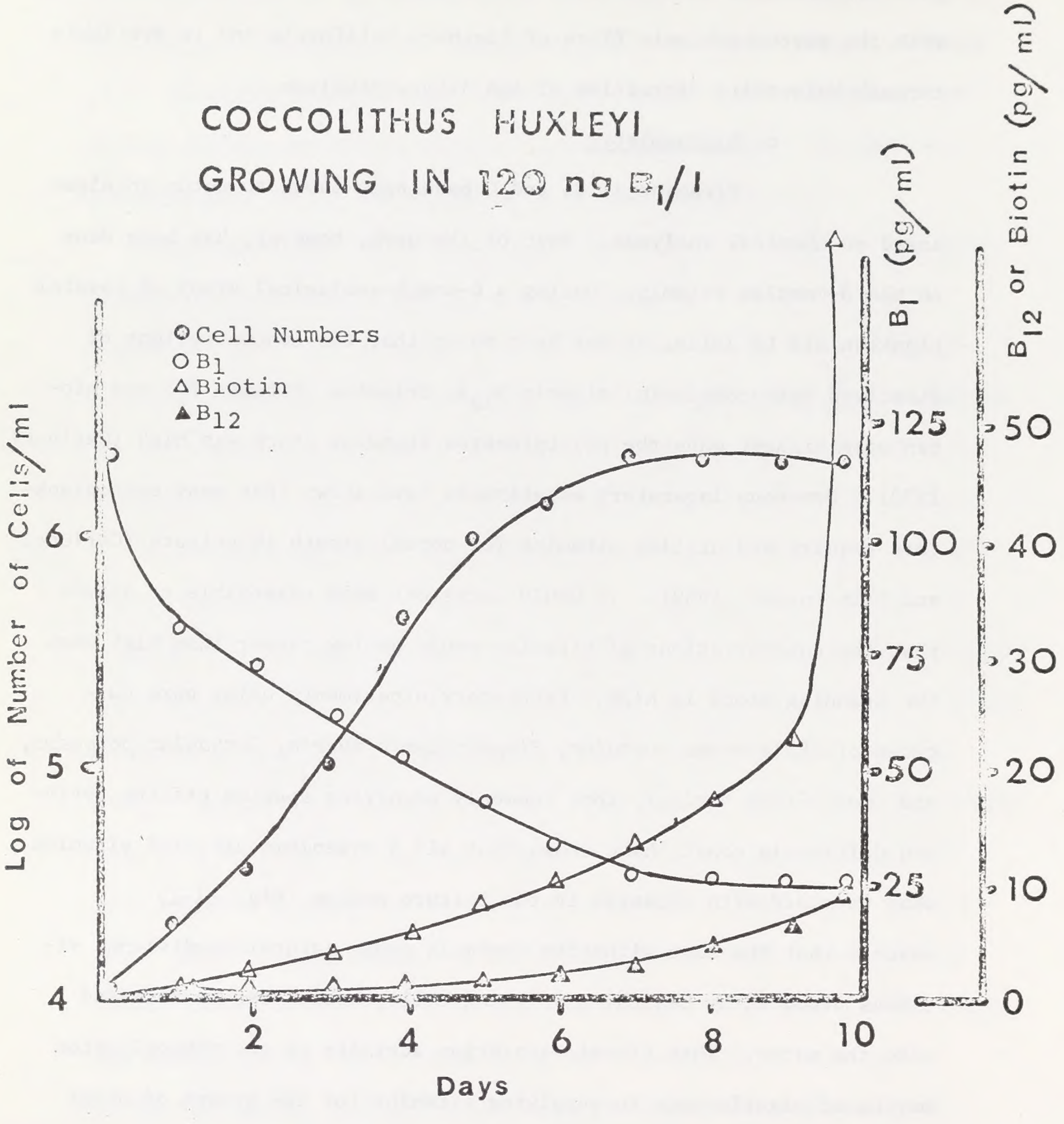

Figure E1-1. Uptake of thiamine (B_1) and production of vitamin B_{12} and biotin by cells of *Coccolithus huxleyi* growing with 120 ng thiamine/liter. After Carlucci and Bowes (1970a).

vitamins can vary appreciably (Carlucci and Bowes, 1972).

Other studies have shown that vitamins in seawater of pH 8 are unfavorably affected by solar radiation (Carlucci et al., 1969). Sunlight destroyed 50% of the activity of vitamin B_{12} and biotin and 70% of the thiamine activity. High concentrations in the field may be stable photodecomposition products or they may be the result of measuring the vitamins before they are broken down by light.

Another experiment has shown inhibitory effects on the vitamin producer or vitamin utilizer in culture (Carlucci and Bowes, 1970b). That *Coccolithus huxleyi* could inhibit the growth of *Skeletonema costatum* and that *Phaeodactylum tricornutum* could inhibit the growth of *Coccolithus huxleyi* in culture has been shown. This is thought to be due to the production of toxins in the medium. Because of the possible presence of these inhibitors and the aforementioned action of sunlight, the amounts of vitamins excreted into the water do not necessarily reflect the amounts available to other organisms.

2. Zooplankton

Sampling programs and literature sources

The literature on zooplankton off Southern California is represented, in large part, by studies on the major toxonomic groups from several sampling programs. The California Cooperative Oceanic Fisheries Investigations (abbreviated heareafter as CalCOFI) is the largest of these programs and has been in existence since 1949. A grid of station locations off California and Baja California was established in 1950 and included 27 stations over the Southern California borderland. For the purposes of this report, these station locations were assigned the station numbers 1 to 27 (see Fig. E1-2). During the first year of the CalCOFI program, 1949, a more restrictive grid of stations was employed and included only four stations over the Southern California borderland. These stations are plotted in Figure E1-2 and were assigned the numbers 28 to 31. All samples taken in the CalCOFI program represent oblique tows taken with a 1-m conical plankton net (0.6-mm mesh) to a depth of 70 m (during 1949) or 140 m (since 1950) (Fleminger, 1964). The volume of water filtered during these oblique tows was quite variable, and for tows to 140 m the volume could range (McGowan, 1967) from about 450 to 950 m^3. The major taxonic groups were investigated separately and were included in a series of zooplankton distributional atlases for the Copepoda (Fleminger, 1964, 1967), Euphausiacea (Brinton, 1967), Thalicea (Berner, 1967), Mollusca (McGowan, 1967), and Chaetognatha (Alvarino,1965). The Amphipoda were reported in an unpublished Ph.D. thesis by Bowman (1953). The heteropod

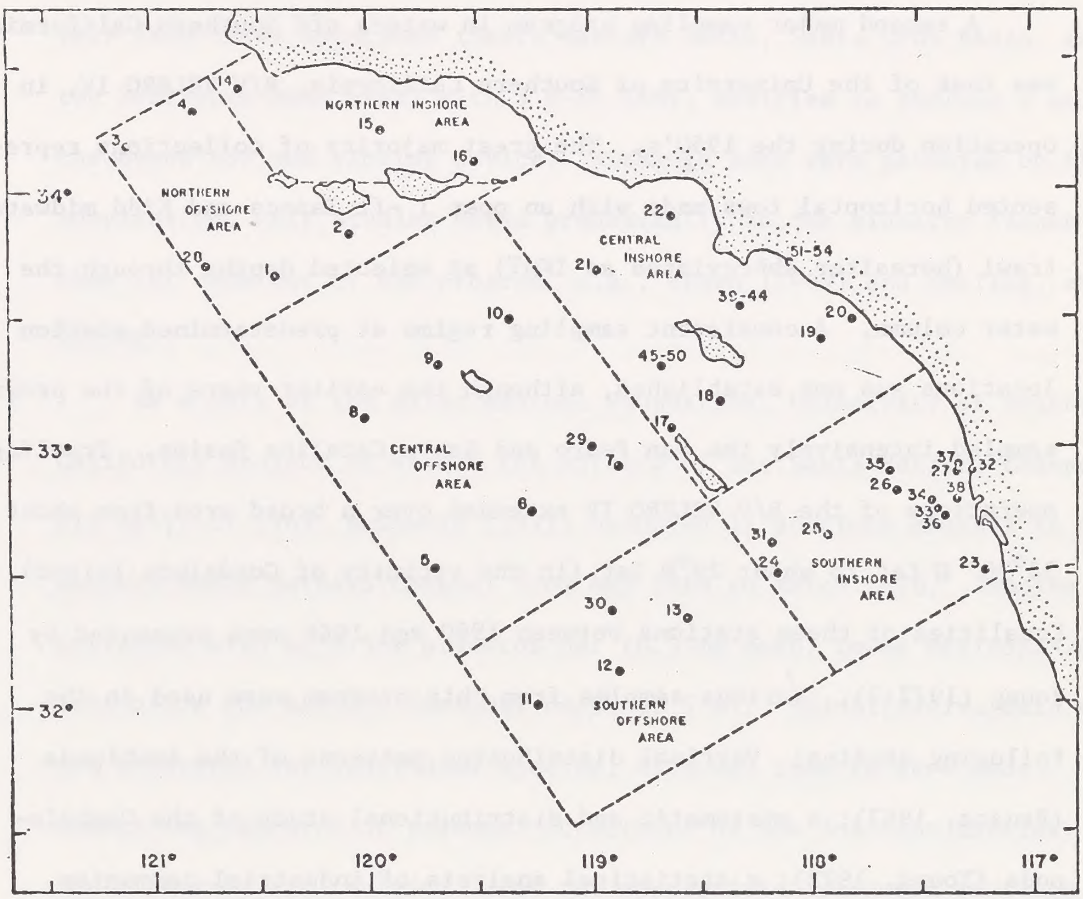

Figure E1-2. Sampling locations for cited studies and their assigned station numbers off Southern California. Stations are grouped into 3 inshore and 3 offshore areas. The southwesterly boundary of the study area roughly parallels the Patton Escarpment. From: Seapy (1974).

mulluscs collected during the first year of the CalCOFI program were studied by Dales (1957).

A second major sampling program in waters off Southern California was that of the University of Southern California, R/V VELERO IV, in operation during the 1960's. The great majority of collections represented horizontal tows made with an open 1 -ft Isaacs and Kidd midwater trawl (hereafter abbreviated as IKMT) at selected depths through the water column. A consistent sampling regime at predetermined station locations was not established, although the earlier years of the program sampled intensively the San Pedro and Santa Catalina Basins. Trawling operations of the R/V VELERO IV extended over a broad area from about 33°30' N Lat to about 29°N Lat (in the vicinity of Guadalupe Island). Localities of these stations between 1960 and 1966 were presented by Young (1972:2). Various samples from this program were used in the following studies: Vertical distribution patterns of the Amphipoda (Brusca, 1967); a systematic and distributional study of the Cephalopoda (Young, 1972); a statistical analysis of industrial community structure and distribution (Ebeling, et al., 1970a); seasonal patterns (Seapy, in press); day-night and basin variability in replicated 10-ft. IKMT oblique tows to a depth of 650m for decapod crustaceans (Atsatt and Seapy, in press).

The third major sampling program in Southern California waters was that of the University of California, Santa Barbara, R/V SWAN, in operation from 1964 to 1969. Samples were collected at monthly intervals from three locations (Santa Barbara Basin, Santa Cruz Basin, and the Rodriquez Dome area) with a 6-ft IKMT, modified to include a multi-chambered cod end closing device. Although data were gathered on the zooplankton, only studies based predominatly on the midwater fishes have thus far come out of the program, e.g., Brown (1969) and Ebeling, et al. (1970b).

As a part of the Allan Hancock Foundation, University of Southern California project to assess the effects of the Santa Barbara Channel oil spill of 1969, McGinnis (1971) occupied 11 stations monthly in the eastern Santa Barbara Channel from May 1969 to March 1970. Samples were collected with an 0.5-m plankton net (0.33mm mesh) towed horizontally just below the surface (maximal depth of 5 m). Quantitiative data were not presented for individual species, although remarks were made concerning patterns of seasonal occurrence of the dominant species. These remarks are included under the appropriate taxonomic sections below. One other Allan Hancock Foundation study (1965) was a survey of the Southern California mainland shelf during 1956 to 1960 and included data on microzooplankton (unidentified larval polychaetes, pelecypods) and unidentified adult copedpods, medusae, larvaceans, and cladocerans. These data are not discussed in this report.

A number of studies on nearshore zooplankton were conducted at San Diego during the 1900's to 1920's, resulting in publications on the Copepoda (Esterly 1905, 1911, 1912, 1917, 1923, 1928), Ctenophora

(Torrey 1904, Esterley 1914a), "Schizopoda" (Esterly 1914b), Ostracoda (Juday,1906), and Chaetognatha (Michael,1911, 1913). Only the 1923 paper on the copepods *Acartia tonsa* and *Acartia clausi* by Esterly contained quantitative data on abundance that could be compiled for the purposes of the present report. Abundance data were collected by Esterly (1923) by towing a 14-in diameter #000 plankton net at the surface for a distance of 80 ft. along the pier at the Scripps Institution of Oceanography. Data were collected monthly over a two-year period (September 1916 to August 1918). The Scripps pier was assigned Station number 32 (see Fig. E1-2 of this report).

Studies on the abundances of populations of the copepod *Calanus helgolandicus* off La Jolla have been conducted by Mullin and Brooks (1970, 1972). In the 1970 study two stations (located approximately 3 nautical miles northwest and 6 nautical miles west of the pier at Scripps Institution of Oceanography) were occupied twice each week from 18 April to 18 August 1967. Samples for copepodite stages of C. *helgolandicus* were collected with paired BONGO 0.7-m nets (0.183-mm mesh) lowered in a closed position and then raised obliquely from a depth of about 300 m (at the inshore station) or 350 m (at the offshore station) to the surface, filtering about 300 m^3 per net. Samples for naupliar stages were collected with paired 0.5-m nets (0.102-mm mesh) by lowering the net with the cod end directed downward to a depth of 100 m and then raised vertically to the surface, filtering about 25 m^3 per net. The resultant counts for the various stages were converted to organic carbon biomass and summed for the water column beneath 1 m^2 of the water surface.

In the 1972 paper, samples were taken at six stations off La Jolla (assigned Station numbers 32 to 37 for the present paper, see Fig. E1-2) with a submersible pump system. The pump was lowered to 50-m depth (except at the first station, which began at 40-m depth), and samples were collected at 5-m intervals to the surface and passed through a modified plankton net with 0.73-mm mesh. Included in the counts (numbers in 150 1) of juvenile *C. helgolandicus* were naupliar stages III to VI and copepodite stages I and II. For the purposes of this report, the abundance value for the depth of maximal numbers was used (see section below on copepods). One nighttime sample was collected (at Station 35 in Fig. E1-2) and individuals were shown to be fairly evenly distributed between the surface and 50 m, while during the day peaks of abundance occurred variously at 35 to 40 m (Stations 33 and 34 of Fig. E1-2) at the surface (Station 36 of Fig. E1-2), and at 15 to 20 m (Stations 37 and 38 of Fig. E1-2). The depths of maximal abundance were positively correlated with the depths of high phytoplankton biomass at each station.

The only sampling program identified for a bay or estuary in Southern California was for Anaheim Bay. Results of an 11-month sampling program by staff and students at California State University at Long Beach were reported in four unpublished M.S. theses on the Copepoda (Howey, 1971), Cladocera (Slawson, 1972), larval Decapoda (Sowby, 1973), and Chaetognatha (Felts, 1973). Monthly or bimonthly samples were collected from 1969 to May 1970 at four stations (Fig. E1-3). These stations have been assigned Station numbers 51-54 for the purposes of this report (see Fig. E1-2). Samples were collected with an 0.5-m net (0.43-mm mesh) towed near the surface (maximal depth of 3 m), that filtered from 20 to 60 m°. Arco, in written testimony, indicated that sampling programs are now underway and have been for at least 2-3 years in King Harbor, Santa Monica Bay (John Stephens, Occidental College, Los Angeles, and in Los Angeles-Long Beach Harbor, in San Pedro Bay (Allan Hancock Foundation and J. Stephens, Occidental College). Abundance data were compiled from these studies and are presented under the appropriate taxonomic sections in Section II.E.2. of this statement.

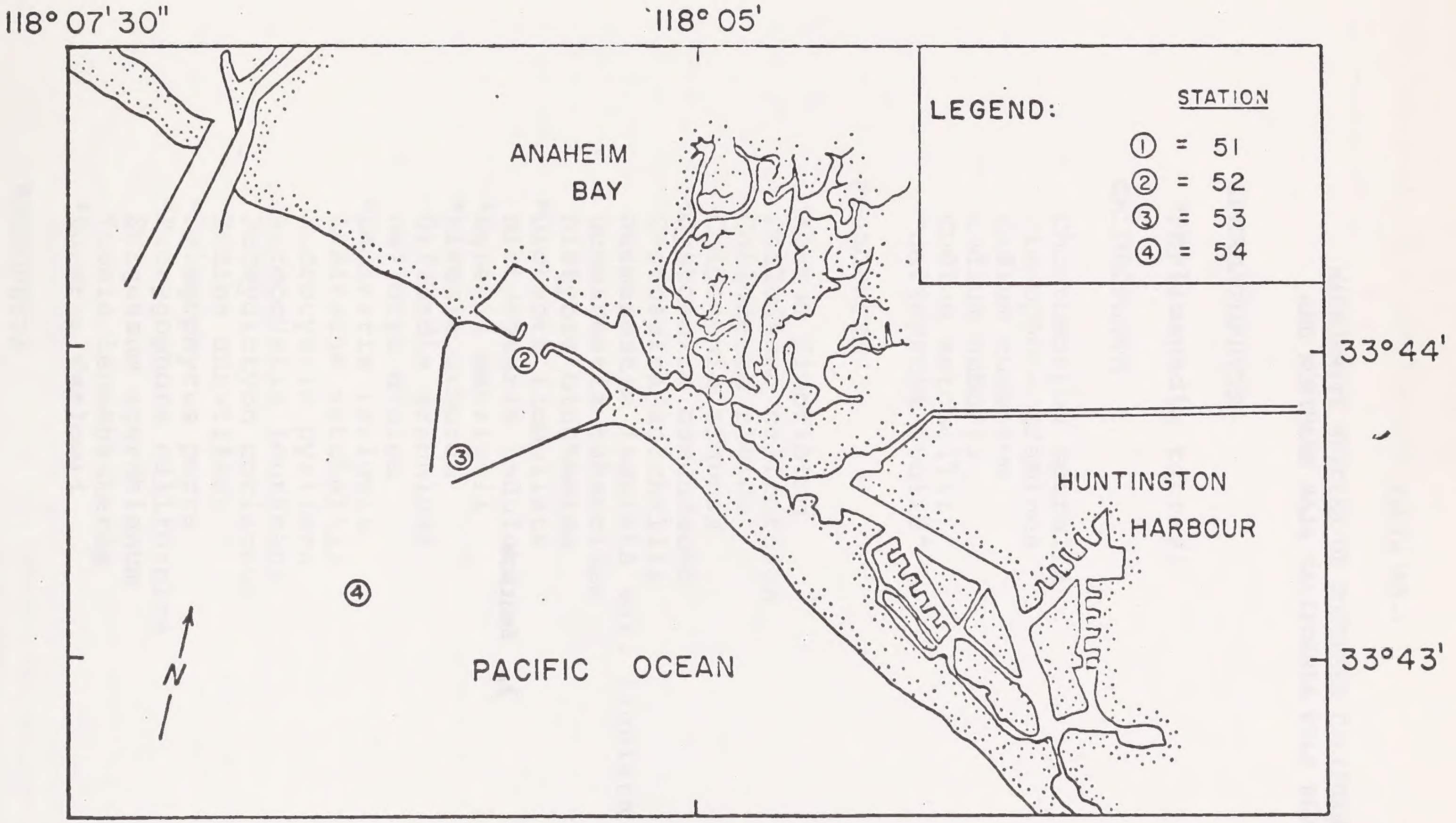

Figure E1-3. Locations of the four stations used in the California State University, Long Beach study of Anaheim Bay.
From: Seapy (1974)

3. Benthos

Table E3-1

MACROPHYTE SPECIES OF SOUTHERN CALIFORNIA AND NORTHERN BAJA CALIFORNIA KELP BEDS

From: Murray (1974c)

SPERMATOPHYTA

*Phyllospadix torreyi

CHLOROPHYTA

Chaetomorpha spiralis
Cladophora graminea
Codium cuneatum
Codium hubbsii
Codium setchellii
"Halicystis ovalis"

PHAEOPHYTA

Agarum fimbriatum
Coilodesme californica
Coilodesme rigida
Colpomenia sinuosa
*Cystoseira osmundacea
Cystoseira setchellii
Desmarestia ligulata var. ligulata
Desmarestia tabacoides
Dictyota binghamiae
*Dictyota flabellata
Dictyopteris undulata
*Egregia menziesii
*Eisenia arborea
Giffordia granulosa
Halidrys dioica
*Laminaria farlowii
Laminaria setchellii
Macrocystis pyrifera
Nereocystis leutkeana
Pachydictyon coriaceum
Padina durvillaei
*Pelagophycus porra
*Pterygophora californica
Sargassum agardhianum
Taonia lennebackerae
*Zonaria farlowii

RHODOPHYTA

*Acrosorium uncinatum
Amphiroa zonata

Table E3-1 (Cont'd)

Amplisiphonia pacifica
Anisocladella pacifica
Antithamnionella glandulifera
Binghamia forkii
*Bossiella orbigniana ssp. dichotoma
*Bossiella orbigniana ssp. orbigniana
Botryocladia neushulii
Botryocladia pseudodichotoma
Botryoglossum farlowianum
Branchioglossum undulatum
*Calliarthron cheilosporioides
*Calliarthron tuberculosum
Callithamnion sp.
Callophyllis firma
Callophyllis flabellulata
Callophyllis violacea
Carpopeltis bushiae
Ceramium pacificum
Chondria californica
Chondria nidifica
*Corallina officinalis var. chilensis
*Coralline vancouveriensis
Cryptonemia angustata
Cryptonemia obovata
Cryptopleura crispa
Cryptopleura violacea
Fauchea lacinata
Fryeela gardneri
Gastroclonium coulteri
Gelidium nudifrons
Gelidium robustum
Gelidium purpurascens
Gigartina canaliculata
Gigartina corymbifera
Gigartina serrata
Gigartina spinosa
Gigartina volans
Gracilaria sjoestedtii
Gracilaria textorii var. cunninghamii
Gracilariophila oryzoides
Grateloupia howeii
Grateloupia schizophylla
Griffithsia pacifica
Gymnogongrus leptophyllus
Haliptylon gracilis
Laurencia spectabilis var. diegoensis
Laurencia splendens
Laurencia subopposita
Leptocladia binghamiae
Lithophyllum imitans
Lithothamnium giganteum

Table E3-1 (Cont'd)

Lithothrix aspergillum
Maripelta rotata
Melobesia mediocris
Mesophyllum lamellatum
Microcladia coulteri
Myriogramme caespitosa
Neoagardhiella baileyi
*Peyssonelia rubra
Phyllophora californica
Phyllophora clevelandii
*Plocamium cartilagineum
Pogonophorella californica
Polyneura latissima
Polysiphonia johnstonii
Polysiphonia mollis
Prionitis andersoniana
Prionitis cornea
Prionitis lanceolata
Prionitis linearis
Pseudogloiophloea confusa
Pterochondria woodii var. pygmaea
Pterochondria woodii var. woodii
Pterocladia capillacea
Pterosiphonia baileyi
Pterosiphonia dendroidea
Rhodymenia arborescens
Rhodymenia californica var. attenuata
Rhodymenia californica var. californica
*Rhodymenia pacifica
Schizymenia pacifica
Sciadophycus stellatus
Scinaea johnstoniae
Smithora naiadum
Stenogramme interrupta
Tenarea dispar
Tiffaniella snyderae

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*Species marked with an asterisk are considered to be common in kelp beds.

Table E3-2

CONCENTRATIONS OF DDT AND PCB HAVING LETHAL AND SUBLETHAL EFFECTS ON MARINE OR ESTUARINE INVERTEBRATES IN THE LABORATORY*

Concentration (ppb)	Response	Organism	Reference
DDT (in seawater)			
Lethal			
3.3-10	48-hr LC_{50}	European brown shrimp, Crangon crangon	Portmann 1970
1	48-hr LC_{50}	Sand shrimp, Crangon septemspinosa	Eisler 1969
5.1	48-hr LC_{50}	Grass shrimp, Palaemonetes vulgaris	Eisler 1969
6	48-hr LC_{50}	Hermit crab, Pagurus longicarpus	Eisler 1969
0.12	28-day LC_{100}	Shrimp sp.	Nat.Acad.Sci.1971
0.25	No long-term mortality	Crab larvae, Cancer magister and C. productus	Poole & Odemar 1970
5	72-hr LC_{100}	Crab larvae, Cancer magister C. productus	Poole & Odemar 1970
10,000	48-hr LC_{50}	European cockle, Cardium edule	Portmann 1970
10,000	96-hr LC_{50}	Quahog clams, Mercenaria mercenaria, & mud snails, Nassa obsolete	Eisler 1970
34	14-day LC_{50}	Oyster larvae, Crassostrea	Davis & Hidu 1969
Sublethal			
0.01	Inhibition of development	Copepod larvae, Pseudodiaptomus	Nat.Acad.Sci.1971

Table E3-2 (Continued)

Concentration (ppb)	Response	Organism	Reference
25	50% decrease in growth, 12 days	Oyster larvae,Crassostrea virginica	Davis & Hidu 1969
1	20% decrease in growth,3-4 days	Oyster adults,Crassostrea virginica	Butler 1966
1000	90% decrease in growth,3-4 days	Oyster adults,Crassostrea virginica	Butler 1966
2	Effect on glycolytic & gluconeogenic enzymes	Quahog clams	Engel et al. 1970
PCB (in seawater)			
Lethal			
300 - 10,000	48-hr LC_{50}	European brown shrimp	Portman 1970
3000 - 10,000	48-hr LC_{50}	European cockle	Portman 1970
100	48-hr LC_{100}	Juvenile pink shrimp	Duke et al.1970
5	20-day LC_{72}	Juvenile pink shrimp	Duke et al. 1970
Sublethal			
1	20% decrease in shell growth	Oyster sp.	Duke et al. 1970
DDT (in food)**			
10,000	Behavioral changes, 11-days	Fiddler crab,Uca Pugnax	Odum et al. 1969
7,000	Development abnormalities & lower survival	Larvae of 4 crab spp.	Bookhout & Costlow 1970
2,300	No effect	Larvae of 4 crab spp.	Bookhout & Costlow 1970
2,000	15-day LC_{50}	Brown shrimp,Peneaus azetecus,& blue crab, Calinectes sapidus	Butler 1969

* From SCCWRP,1973

Total residues in detritus or prey.

Table E3-3

RELATIVE TOXICITIES OF TEN METALS IN SEAWATER TO MARINE AND ESTUARINE ORGANISMS+

Organism and Response	Metal and Concentration (ppm)						Reference
Abnormal development of sea urchin embryos	Silver	Mercury	Copper	Zinc	Iron, Chromium	Manganese	
Species 1		0.032	0.1	0.32	10	32	Okubo & Okubo 1962
Species 2		0.032	0.032	1.0			Okubo and Okubo 1962
Species 3	0.00016	0.0015					Wilber 1969
Abnormal development of Mytilus edulis embryos		Mercury	Copper	Zinc	Chromium	Iron, Manganese	
		0.032	0.1	1.0	10	32	Okubo & Okubo 1962
Abnormal development of oyster (Crassostrea Commercialis) embryos		Mercury	Copper	Zinc			
		0.032	0.1	3.2			Okubo & Okubo 1962
Bryozoan larvae, 2-hr LC_{50}*		Mercury	Copper	Zinc			
		0.1	0.57	32.7			Wisely and Blick 1967
Tubeworm larvae, 2-hr LC_{50}		Mercury	Copper	Zinc			
		0.14	0.51	4.9			Wisely and Blick 1967
European brown shrimp (Crangon crangon) 48-hr LC_{50}		Mercury	Copper	Iron	Chromium	Nickel, Zinc	
		3.3-10	10-33	33-100	100	100-330	Portmann 1970
European cockle (Cardium edule) 48-hr LC_{50}		Mercury	Copper	Chromium, Iron, Zinc		Nickel	
		3.3-10	1.0	100-330		330	Portmann 1970

+ From SCCWRP, 1973

*The concentration resulting in 50% mortality of the test organisms within 2 hours.

Table E3-3 (continued)

Concentration (ppb)	Response	Organism	Reference
25	50% decrease in growth, 12 days	Oyster larvae, Crassostrea virginica	Davis & Hidu 1969
1	20% decrease in growth, 3-4 days	Oyster adults, Crassostrea virginica	Butler 1966
1000	90% decrease in growth, 3-4 days	Oyster adults, Crassostrea virginica	Butler 1966
2	Effect on glycolytic & gluconeogenic enzymes	Quahog clams	Engel et al. 1970
PCB (in seawater)			
Lethal			
300 - 10,000	48-hr LC_{50}	European brown shrimp	Portman 1970
3000 - 10,000	48-hr LC_{50}	European cockle	Portman 1970
100	48-hr LC_{100}	Juvenile pink shrimp	Duke et al.1970
5	20-day LC_{72}	Juvenile pink shrimp	Duke et al. 1970
Sublethal			
1	20% decrease in shell growth	Oyster sp.	Duke et al. 1970
DDT (in food)**			
10,000	Behavioral changes, 11-days	Fiddler crab, Uca Pugnax	Odum et al. 1969
7,000	Development abnormalities & lower survival	Larvae of 4 crab spp.	Bookhout & Costlow 1970
2,300	No effect	Larvae of 4 crab spp.	Bookhout & Costlow 1970
2,000	15-day LC_{50}	Brown shrimp, Peneaus azetecus, & blue crab, Calinectes sapidus	Butler 1969

* From SCCWRP, 1973

**Total residues in detritus or prey.

4. Nekton

Table E4-1 From: Horn (1974)

FISH FAMILIES KNOWN TO OCCUR IN SOUTHERN CALIFORNIA WITH ADAPTIVE ZONE(S) AND DEPTH RANGE, NUMBER OF SPECIES RECORDED IN SOUTHERN CALIFORNIA WATERS, AND FOOD ITEMS BY MAJOR CATEGORY.

			FOOD ITEMS[1]															
			ZOOPLANKTON					NEKTON				BENTHOS						
Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Myxinidae	Benthic 30 to 2400	3						X					X					
Petromyzontidae	Pelagic	1						X					X					
Hexanchidae	Bays, shallow to 960	2																
Chlamydoselachidae	Shallow to 1650	1																
Heterodontidae	Demersal, shallow to 492	1											X		X			
Squalidae	Neritic, shallow to 1200	4											X					
Squatinidae	Neritic, shallow	1											X					
Alopiidae	Epipelagic	2						X										

Table E4-1 Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number Of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Sphrynidae	Pelagic	2						X										
Cetorhinidae	Epipelagic	1							X									
Rhincodontidae	Epipelagic	1							X									
Scyliorhinidae	Neritic, shallow to 1380	4											X					
Lamnidae	Epipelagic	3						X										
Odontaspidae	Epipelagic	1						X										
Carcharhinidae	Neritic, shallow to 210	12						X					X		X			
Torpedinidae	Demersal, shallow to 640	1						X					X					
Platyrhinidae	Shallow to 150	1																
Rhinobatidae	Demersal, 0 to 150	2												X	X	X		

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Rajidae	Demersal, 60 to 4500	8											X		X			
Mobulidae	Epipelagic	2																
Mylio-batidae	Demersal, 0 to 150	1												X	X			
Dasyati-didae	Demersal, 0 to 70	3											X	X	X	X		
Gymnuri-dae	Bays, Beaches	1																
Chimaer-idae	Demersal, shallow to 1200	1											X	X	X			
Acipense-ridae	Shallow to 400	2																
Albulidae	Shallow	1																
Muraeni-dae	Rocky Demersal	1											X		X			
Congridae	Sandy Demersal, 30 to 1200	1																

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)1	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Nemichthyidae	Lower mesopelagic, 300 to 6000	2							X									
Ophichthidae	Intertidal and shallow to 60	3																
Nettastomatidae	Benthopelagic	1							X									
Serrivomeridae	Bathypelagic 0 to 1000+	1						X	X	X								
Clupeidae	Neritic	7	X	X	X	X	X						X					
Engraulidae	Neritic, bays, shallow	3	X	X	X	X	X (phytoplankton)		x									
Salmonidae	Pelagic	5																
Alepisauridae	Meso-to bathypelagic, 0 to 6000	1					X	X	X		X							

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Alepocephalidae	Bathy-to bentho-pelagic, 150 to 18,000	3							X									
Searsiidae	Mesopelagic, 200 to 3000	3							X									
Osmeridae	Neritic	2																
Argentinidae	Upper mesopelagic, 36 to 900	3							X									
Bathylagidae	Mesopelagic, 0 to 3280	5							X									
Opisthoproctidae	Mesopelagic, 324 to 2940	2		X														
Gonostomatidae	Meso- to bathy pelagic, 180 to 3412	6	X	X			X											
Sternoptychidae	Mesopelagic, 330 to 2400	7		X	X			X	X									
Melanostomiatidae	Bathypelagic, 102 to 2000	3							X									
Malacosteidae	Bathypelagic, 500 to 1000+	1							X									

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersalfish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Chauliodontidae	Bathypelagic 240 to 5000	1						X	X	X								
Stomiatidae	Lower mesopelagic, 500 to 1000	1						X	X									
Idiacanthidae	Lower mesopelagic	1						X	X									
Anotopteridae	Epi- to mesopelagic	1			X			X										
Paralepididae	Bathypelagic, 200 to 1500	1			X			X	X	X								
Scopelarchidae	Bathypelagic, > 1000	1						X	X									
Scopelosauridae	Mesopelagic	1						X	X									
Synodontidae	Rocky, Sandy, demersal, 5 to 150	1						X		X			X					

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersalfish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Myctophidae	U-meso-Bathy pelagic, 0 to 9500	16		X				X	X		X							
Neoscopelidae	Lower meso-pelagic, >1500	1							X									
Batrachoididae	Rocky, sandy, demersal, shallow to 1000	2						X							X			
Ophidiidae	Benthic, 4 to 800	2											X	X	X			
Brotulidae	Benthopelagic, 10 to 840	2											X		X			
Ariidae	Neritic	1																
Gobiesocidae	Rocky, sandy, demersal, intertidal to 35	7												X	X			
Macrouridae	Benthopelagic, 200 to 2000	2											X					

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Moridae	Benthopelagic 1000 - 10,000	2											X		X			
Merlucciidae	Sandy, dermersal, shallow to 3000	1						X		X			X		X			
Gadidae	Pelagic, 0 to 1200	1											X	X	X			
Zoarcidae	Benthic, 30 to 7200	10												X				
Exocoetidae	Epipelagic	4											X		X			
Hemirhamphidae	Epipelagic	4																
Belonidae	Epipelagic, 0 to 300	1						X	X									
Scomberesocidae	Epipelagic	1		X	X													
Cyprinodontidae	Bays, shallow	1																

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range[1] (ft)	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Atherinidae	Neritic, shallow	3	X	X	X	X	X					X						
Antennariidae	Benthic, near surface to 360	1																
Ogcocephalidae	Benthic, 60 to 372	1																
Ceratiidae	Bathypelagic 1440 to 5000	1																
Oneirodidae	Meso-to bathy-pelagic, >1000	2							X									
Oreosomatidae	Pelagic, to 1800	1																
Zeidae	Pelagic, 100 to 1000+	1						X										
Lampridae	Pelagic, 0 to 1680	1						X	X	X								
Melamphaidae	Meso-to Bathy-pelagic, 390 to 6000	9							X									

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Anoplo-gasteridae	Bathypelagic, >2000	1						X	X	X								
Lopho-tidae	Pelagic,0 to 300	1						X		X								
Regalec-idae	Pelagic,0 to 1350	1							X									
Trachi-pteridae	Pelagic,0 to 300	4						X	X	X								
Gastero-steidae	Sandy,inshore, 0 to 100	2		X	X													
Centris-cidae	Pelagic, 0 to 700	1							X									
Syngna-thidae	Rocky,inshore, sandy bays, shallow	5													X			
Scorp-aenidae	Demersal, shallow to 5000	55				X		X			X		X	X	X	X	X	
Triglidae	Demersal 48 to 360	2																
Anoplop-omatidae	Demersal 0 to 1440	1		X	X	X	X						X		X	X		

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Zaniolepididae	Demersal shallow to 1200	2																
Hexagrammidae	Demersal, intertidal to 1400	3										X	X	X	X	X		
Cottidae	Demersal, intertidal to 1224	34											X	X	X	X		
Agonidae	Demersal, 30 to 1224	8													X	X		X
Liparididae	Demersal, Intertidal to 5256	3													X			
Serranidae	Inshore, 0 to 600	10						X					X	X	X	X	X	
Priacanthidae	84 to 198	1																
Apogonidae	30 to 60	1																

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)^1	Number Of Species^1	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Branchiostegidae	Rocky, sandy, inshore, 0 to 300	1						X		X			X	X	X			
Echeneidae	Epipelagic	7						X	X									
Carangidae	Pelagic, 0 to 150	13					X	X	X	X								
Nematistiidae	Shallow, inshore	1																
Coryphaenidae	Epipelagic	1						X	X	X								
Bramidae	Pelagic	3						X	X	X								
Gerreidae	Shallow, inshore	2																
Pristipomatidae	Neritic, surface to 130	2										X		X	X	X	X	
Sparidae	Neritic, Shallow to 225	1																
Mullidae	Shallow, inshore	1																

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)^1	Number of Species^1	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Ephippidae	Shallow, inshore	1																
Sciaenidae	Sandy, inshore, 0 to 400	8						X				X	X		X			
Girellidae	Sandy, inshore, intertidal to 95	1										X		X	X	X	X	X
Kyphosidae	Shallow, Inshore, to 25	1																
Scorpididae	Neritic, inshore, 0 to 130	1			X							X			X	X	X	
Chaetodontidae	Shallow to 492	2																
Pentacerotidae	Shallow to 1320	1																
Embiotocidae	Sandy, rocky, inshore	18												X	X	X		

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostrcods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Pomacentridae	Rocky, sandy, inshore, 0 to 150	2			X							X		X	X		X	
Mugilidae	Inshore, demersal	1										X		X	X	X	X	X
Sphyraenidae	Epipelagic, 0 to 60	1						X										
Polynemidae	Shallow	2																
Labridae	Rocky, inshore, 0 to 180	3										X		X	X		X	
Bathymasteridae	Rocky, Sandy, inshore, 60 to 540	3		X	X	X										X		
Uranoscopidae	Sandy, demersal, 42 to 1260	1						X		X			X					
Anarchichadidae	Demersal, inshore to 400	1																

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Blenniidae	Rocky, demersal	3			X										X	X		
Clinidae	Rocky, sandy demersal	12			X							X		X	X	X		
Cebidichthyidae	Rocky, demersal, intertidal to 80	1																
Stichaeidae	Rocky, sandy, demersal, intertidal to 900	8										X			X	X		
Pholidae	Rocky, sandy, demersal, intertidal to 120	3		X											X			X
Ammodytidae	Neritic, shallow to 60	1																
Eleotridae	Inshore	1																

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species[1]	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Icosteidae	Pelagic, 60 to 1200	1																
Gobiidae	Sandy, rocky, demersal, intertidal to 318	13												X	X	X		
Trichiuridae	Pelagic, 18 to 1260	3						X	X									
Gempylidae	Pelagic, shallow to 3300	2																
Scombridae	Pelagic	14						X	X	X								
Xiphiidae	Pelagic, 0 to 2000	1						X		X								
Istiophoridae	Pelagic	5						X	X	X								
Luvaridae	Pelagic	1									X							
Centrolophidae	Pelagic	1							X		X							

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)^1	Number of Species	Ostracods	Copepods	Larval fish/eggs	Larval inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Tetragonuridae	Pelagic	1									X							
Stromateidae	Pelagic 30 to 300	1							X		X							
Cynoglossidae	Sandy, demersal, 5 to 276	1													X			
Bothidae	Demersal, 0 to 1800	6						X					X	X	X	X		X
Pleuronectidae	Demersal, 0 to 3000	18											X	X	X	X	X	
Balistidae	Shallow, inshore	3																
Tetraodontidae	Shallow, inshore	2																
Diodontidae	Shallow, inshore	2																
Ostraciidae	Inshore, shallow to 90	1																

Table E4-1 (Cont'd.)

Family	Adaptive Zone and Depth Range (ft)[1]	Number of Species	Ostracods	Copepods	Larval fish/eggs	Larval Inverts.	Other	Pelagic fish	Crustaceans	Cephalopods	Other	Algae	Demersal fish	Mollusks	Crustaceans	Polychaetes	Echinoderms	Other
Molidae	Epipelagic	2						X	X		X							

TOTAL FAMILIES = 150

TOTAL SPECIES = 528

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[1] Data from various sources: Miller and Lea(1972), Ebeling, et al. (1970b), Paxton (1967 a and b), Lavenberg and Ebeling (1967), Fitch and Lavenberg (1968 and 1971), Frey(1971), Pinkas, et al.(1971), Quast (1968d),Turner,et al. (1969).

Table E4-2

FREQUENCY OF OCCURRENCE (PERCENT) OF THE 20 SPECIES MOST COMMON IN SAMPLES FROM THE 1969-72 TRAWLING SURVEYS BY SCCWRP (1973a) IN SOUTHERN CALIFORNIA COASTAL WATERS

Rank	Species	All Areas	Port Hueneme	Santa Monica Bay	Palos Verdes	San Pedro Bay	Santa Catalina Island
1	Dover sole (*Microstomus pacificus*)	66	16	55	84	73	52
2	Pacific sanddab (*Citharichthys sordidus*)	57	72	31	68	53	91
3	Speckled sanddab (*Citharichthys stigmaeus*)	55	80	74	45	55	10
4	Plainfin Midshipman (*Porichthys notatus*)	49	20	74	34	52	57
5	English sole (*Parophrys vetulus*)	48	68	33	46	56	0
6	California tonguefish (*Symphurus atricauda*)	48	64	57	13	64	5
7	Hornyhead turbot (*Pleuronichthys verticalis*)	46	84	45	22	61	19
8	Pink Seaperch (*Zalembius rosaceus*)	42	32	35	30	48	76
9	Stripetail rockfish (*Sebastes saxicola*)	36	8	39	36	36	43
10	Yellowchin sculpin (*Icelinus quadriseriatus*)	32	24	53	3	41	81

Table E4-2 (Cont'd.)

Rank	Species	All Areas	Port Hueneme	Santa Monica Bay	Palos Verdes	San Pedro Bay	Santa Catalina Island
11	Shortspine combfish (*Zaniolepis frenata*)	31	16	14	16	41	81
12	Longspine combfish (*Zaniolepis latipinna*)	30	64	33	16	31	19
13	Curlfin sole (*Pleuronichthys decurrens*)	29	72	25	50	12	24
14	Rex sole (*Glyptocephalus zachirus*)	29	8	14	28	41	33
15	Bigmouth sole (*Hippoglossina stomata*)	26	28	12	18	35	48
16	Slender sole (*Lyopsetta exilis*)	25	8	23	12	38	33
17	Shiner perch (*Cymatogaster aggregata*)	24	12	8	33	33	0
18	Halfbanded rockfish (*Sebastes semicinctus*)	23	0	8	22	33	24
19	White croaker (*Genyonemus lineatus*)	22	20	12	22	30	0
20	California scorpion- (*Scorpaena guttata*)fish	20	0	10	28	23	19
	Number of Hauls	303	25	49	76	132	21

Table E4-3

TOTAL NUMBER OF SPECIMENS OF EACH OF THE 20 SPECIES MOST ABUNDANT IN SAMPLES FROM THE 1969-72 TRAWLING SURVEYS BY SCCWRP (1973a) IN SOUTHERN CALIFORNIA COASTAL WATERS

Rank	Species	Number of Specimens
1	Speckled sanddab (*Citharichthys stigmaeus*)	17,626
2	Pacific sanddab (*Citharichthys sordidus*)	10,312
3	Dover sole (*Microstomus pacificus*)	9,375
4	Stripetail rockfish (*Sebastes saxicola*)	5,535
5	White croaker (*Genyonemus lineatus*)	4,155
6	Plainfin midshipman (*Porichthys notatus*)	3,943
7	Slender sole (*Lyopsetta exilis*)	3,893
8	California tonguefish (*Symphurus atricauda*)	3,590
9	Halfbanded rockfish (*Sebastes semicinctus*)	3,310
10	Yellowchin sculpin (*Icelinus quadriseriatus*)	2,836
11	Shiner perch (*Cymatogaster aggregata*)	2,008
12	Pink seaperch (*Zalembius rosaceus*)	1,975
13	Northern anchovy (*Engraulis mordax*)	1,952
14	Rex sole (*Glyptocephalus zachirus*)	1,865
15	Queenfish (*Seriphus politus*)	1,864
16	Longspine combfish (*Zaniolepis latipinnis*)	1,402
17	Splitnose rockfish (*Sebastes diploproa*)	1,186
18	Curlfin sole (*Pleuronichthys decurrens*)	1,063
19	Blackbelly eelpout (*Lycodopsis pacifica*)	849
20	Shortspine combfish (*Zaniolepsis frenata*)	815
	TOTAL	79,554
	TOTAL (ALL SPECIES)	87,418

Table E4-4

REPRODUCTIVE INFORMATION ON 33 SPECIES OF FISHES IN SOUTHERN CALIFORNIA WATERS (COMPILED FROM FREY, 1971).

Common and Scientific Names	Reproductive Type	Maturity Age ♀	Maturity Age ♂	Maturity Length ♀	Maturity Length ♂	Number of eggs or young	Location	Spawning Season[1]	Spawning Frequency
Soupfin Shark (Galeorhinus zyopterus)	ovoviviparous			5ft+	5ft	6 to 52 average 35	Shoal waters	Jan to July (June)	1 time/ yr
Topsmelt (Atherinops affinis)	oviparous	some spawn by 2nd yr					Attach eggs to eel grass, algae, kelp	May to July	
Jacksmelt (Atherinops californiensis)	oviparous					Large masses	Attach eggs to kelp, eel grass	Oct to April	
Grunion (Leuresthes tenuis)	oviparous	end of 1st yr		5in	4.5in	1,600 to 3,600	Beach at night, 2-6 nights after full moon	March to August	6 times/ season 15 day interval
Northern Anchovy (Engraulis mordax)	oviparous	some end 1st yr, all end 2nd yr		4in to 5.5in		4,025 to 21,297	eggs pelagic	every mo. Late winter, early spring	Est. 2 times/ yr

Table E4-4 (Cont'd.)

Common and Scientific Names	Reproductive Type	Maturity Age ♀	Maturity Age ♂	Maturity Length ♀	Maturity Length ♂	Number of eggs or young	Location	Spawning Season[1]	Frequency
Pacific Sardine (Sardinops caeruleus)	oviparous						55°-63°F deep waters within 100 miles of coast		
Pacific Herring (Clupea pallasi)	oviparous						Shallow waters, river run-off, bays & estuaries	winter & spring	
Jack Mackerel (Trachurus symmetricus)	oviparous	50% 2 yrs, all 3 yrs		10in			Between Pt.Conception & Cape San Quintin, Offshore	Jan to Nov (March to July)	More than once during season
Pacific Mackerel (Scomber japonicus)	oviparous	50% 2 yrs, all 3 yrs					Bulk off southern & central Baja, & Gulf of Calif.	Late April to early Aug (May to July)	More than once during season

Table E4-4 (Cont'd.)

Common and Scientific Names	Reproductive Type	Maturity Age		Maturity Length		Number of eggs or young	Location	Spawning Season[1]	Frequency
		♀	♂	♀	♂				
Pacific Saury (*Cololabis saira*)	oviparous					990 to 1,900	Calif. Current region	Feb to July	2 times/ yr
California Halibut (*Paralichthys californicus*)	oviparous	some 3rd or 4th yr, all by 5th or 6th yr	2nd yr	17in	9in		18 to 60 ft of water	Feb to July (May)	
Dover sole (*Microstomus pacificus*)	oviparous	5 yrs		13in	12in	37,000 250,000	deep off-shore areas	Nov to March	
English Sole (*Parophrys vetulus*)	oviparous	3yrs	2yrs	10in	8in	150,000 to 2 million		Oct to May (Jan & Feb)	
Sablefish (*Anoplopoma fimbria*)	oviparous	50% spawn at age 7	50% spawn at age 5	28in	23.5in			Dec to April (Jan & Feb)	

Table E4-4 (Cont'd.)

Common and Scientific Names	Reproductive Type	Maturity Age ♀	Maturity Age ♂	Maturity Length ♀	Maturity Length ♂	Number of eggs or young	Spawning Location	Spawning Season^1	Spawning Frequency
Pacific Hake (Merluccius productus)	oviparous	3 or 4 yrs		20.5in			deeper portion of bathymetric range,600 to 1,650 ft	winter	
Olive Rockfish (Sebastes serranoides)	ovoviviparous	3 or 4 yrs				as many as 650,000		Dec to March	
Vermilion Rockfish (Sebastes miniatus)	ovoviviparous	50% 6 yrs		13in		63,000 1.6 million		Dec to April	
California Scorpionfish (Scorpaena guttata)	oviparous	Spawn by 3rd or 4th yr					lays egg "balloons" at bottom of sea; rise,hatch at surface	April to Aug	
Albacore (Thunnus alalunga)	oviparous			33.5in to 35.4in		2 million	vicinity of subtropical convergence	Jan to June (April)	

Table E4-4 (Cont'd.)

Common and Scientific Names	Reproductive Type	Maturity Age ♀	Maturity Age ♂	Maturity Length ♀	Maturity Length ♂	Number of eggs or young	Spawning Location	Spawning Season[1]	Spawning Frequency
Pacific Bonito (Sarda chiliensis)	oviparous						off southern California and Northern Baja	Jan to May	
Kelp Bass (Paralabrax clathratus)	oviparous	some 2 to 3 yrs old, others 4 or more yrs		7 in			Kelp forests over rough bottoms, depths of 150 ft	April to Fall Months	Larger females more than once/ season, smaller females once/ season
Barred Sand Bass (Paralabrax nebulifer)	oviparous						in school concentrations	April to fall period	
Giant Sea Bass (Stereolepis gigas)	oviparous	spawn when 7-8 yrs old		36in to 38in		as many as 60 million	Shallow waters	June to Sept	
Yellowtail (Seriola dorsalis)	oviparous	Some 2 yrs old, all 3 yrs old				450,000 to 940,000	some dist. offshore, centered off Baja Calif.	July to Oct	After 1st spawning may spawn more than once/ yr

Table E4-4 (Cont'd.)

Common and Scientific Names	Reproductive Type	Maturity Age ♀	Maturity Age ♂	Maturity Length ♀	Maturity Length ♂	Number of eggs or young	Location	Spawning Season^1	Spawning Frequency
California Barracuda (*Sphyraena argentea*)	oviparous	3 yrs old				42,000 to 484,000		April to Sept (May to July)	May spawn more than once/ season
Cabezon (*Scorpaenichthys marmoratus*)	oviparous	63% 3yrs old, all 5yrs old	33% 2yrs old, all 3yrs old			as many as 100,000	rocky subtital areas to depths of at least 20 ft	Oct to April	
White Seabass (*Cynoscion nobilis*)	oviparous			24in	20in		Congregate near shore in specific areas	April to Aug (May to June)	
California Corbina (*Menticirrhus undulatus*)	oviparous	3yrs	2yrs	13in	10in		Off-shore	June to Sept (July to August)	
Spotfin Croaker (*Roncador stearnsi*)	oviparous	Spawn 3yrs	Spawn 2yrs	12.5in	9in		Off-shore	June to Sept	

Table E4-4 (Cont'd.)

Common and Scientific Names	Reproductive Type	Maturity Age ♀	Maturity Age ♂	Maturity Length ♀	Maturity Length ♂	Number of eggs or young	Location	Spawning Season[1]	Spawning Frequency
Yellowfin Croaker (*Umbrina roncador*)	oviparous							Summer months	
White croaker (*Genyonemus lineatus*)	oviparous	Spawn bet. 2 & 3 yrs old		5in to 6in				most of the yr (early spring)	more than once/ season
Barred Surfperch (*Amphistichus argenteus*)	viviparous	2nd yr		5in		4 to 113 Avg.33		March to July	
Walleye Surfperch (*Hyperprosopon argenteus*)	viviparous	4 to 6 mos				5 to 12		May or June	

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[1] Peak spawning period in parentheses

5. Marine and Shore Birds

TABLE E5-1

LISTING OF SPECIES OBSERVED IN THE SANTA BARBARA CHANNEL AREA BY SPECIES GROUPING

From: California Department of Fish and Game, January 28-March 31, 1969, Progress report on wildlife affected by the Santa Barbara oil spill.

SPECIES GROUPINGS	SPECIES
Loon & Grebe	
common loon	Gavia immer
arctic loon	Gavia arctica
red-throated loon	Gavia stellata
horned grebe	Podiceps auritus
eared grebe	Podiceps caspicus
western grebe	Achmophorus occidentalis
Pelagic Species	
black-footed albatross	Diomedea nigripes
sooty shearwater	Puffinus griseus
Xantus' murrelet	Endomychura hypoleuca
pigeon guillemot	Cepphus columba
common murre	Uria aalge
Cormorant & Pelican	
brown pelican	Pelecanus occidentalis
double-crested cormorant	Phalacrocorax auritus
Brandt's cormorant	Phalacrocroax penicillatus
pelegic cormorant	Phalacrocorax pelagicus
Waterfowl	
brant	Branta bernicla
green-winged teal	Anas carolinensis
canvasback	Aythya valisineria
common goldeneye	Bucephala clangula
bufflehead	Bucephala albeola
surf scoter	Melanitta perspicillata
common scoter	Oidemia nigra
white-winged scoter	Melanitta deglandi
ruddy duck	Oxyura jamaicensis
red-breasted merganser	Mergus serrator

TABLE E5-1 (CONTINUED)

SPECIES GROUPING	SPECIES
Water-associated	
great blue heron	Ardea herodias
common egret	Casmerodius albus
Shorebirds	
black oystercatcher	Haematopus bachmani
snowy plover	Charadrius alexandrinus
black-bellied plover	Squatarola squatarola
black turnstone	Arenaria melanocephala
long-billed curlew	Numenius americanus
whimbrel	Numenius phaeopus
spotted sandpiper	Actitis macularia
willet	Catoptrophorus semipalmatus
knot	Calidris canutus
least sandpiper	Erolia minutilla
western sandpiper	Ereunetes mauri
marbled godwit	Limosa fedoa
sanderling	Crocethia alba
northern phalarope	Lobipes lobatus
Gull & Tern	
glaucous-winged gull	Larus glaucescens
western gull	Larus occidentalis
herring gull	Larus argentatus
California gull	Larus californicus
ringed-billed gull	Larus delawarensis
mew gull	Larus canus
Bonaparte's gull	Larus philadelphia
Heermann's gull	Larus heermanni
black-legged kittiwake	Rissa tridactyla
royal tern	Thalasseus maximum

Table E5-2

Number of Birds Recorded on Beach Surveys of the Santa Barbara Area in February and March, 1969*

Locality and Transect Length	Condition	Loons and Grebes	Pelagic Species	Cormorants and Pelicans	Waterfowl	Water-Associated	Shore Species	Terns and Gulls	Unclassified	Total	No. of Birds/Mi.
Dead Birds											
Arroyo Burro 1.1 miles	Oiled	15	0	5	2	1	0	2	0	25	23
Carpinteria 1.1 miles	Oiled	1	0	0	0	0	0	0	0	1	1
Rincon Beach 2.6 miles	Oiled	10	1	1	0	0	0	1	0	13	5
El Capitan 0.9 miles	Control	19	2	6	3	0	1	0	0	31	34
Total		45	3	12	5	1	1	3	0	70	
Living Birds											
Arroyo Burro 1.1 miles	Oiled	23	0	8	2	1	1494	538	0	2066	1878
Carpinteria 1.1 miles	Oiled	3	0	2	0	0	228	554	0	787	715
Rincon Beach 2.6 miles	Oiled	73	1	21	1	0	840	205	8	1149	442
El Capitan 0.9 miles	Control	381	5	260	97	5	1603	488	1	2840	3155
Total		480	6	291	100	6	4165	1785	9	6842	

*Data from California Fish and Game First Interim Report. (1969)

Table E5-2 Continued

Number of Living Birds Recorded on Aerial Surveys of the Santa Barbara Area in February and March, 1969*

Locality and Transect Length	Condition	Loons and Grebes	Pelagic Species	Cormorants and Pelicans	Waterfowl	Water-Associated	Shore Species	Terns and Gulls	Unclassified	Total	No. of Birds/Mi.
Mainland 38.7 miles	Oiled	2851	4	446	323	19	5067	15035	5	23750	614
Channel 81 miles	Oiled	146	83	22	188	0	42	1999	38	2518	31
Island 31.6 miles	Oiled	961	124	1642	141	10	43	18104	116	24141	764
Channel 14.6 miles	Control	37	17	1	4	0	0	215	4	278	19
Mainland 12.2 miles	Control	1749	0	1490	273	8	695	2108	0	6323	518
Total		5744	228	3601	3929	37	5847	37461	163	57010	

*Data from California Fish and Game First Interim Report (1969)

Table E5-3 SPECIES DISTRIBUTION
(From Bender et al. 1974)

Symbols Used

The following tables show the distribution of bird species in each habitat discussed above. Birds which use a specific habitat for most or all of their activities, or whose activities therein are not known, are shown by and X. Birds which usually confine different activities to separate habitats have these activities indicated under the appropriate habitat as follows: F--feeding or foraging, L--loafing, R--roosting, and N--nesting. Table II-61f, Birds of the Channel Islands, is tabulated by the species manner of occurrence, as endemic forms, seasonal residents, etc. Letters in the columns are the same as those used in the annotated species list (Section 5) : e--endemic form, r--permanent resident, b--breeding, and X--migrant or regularly occurring. An exception to this continuity is made for seasonal island residents, which are tabulated as S--summer and W--winter.

TABLE E5-3
OCEAN

	Pelagic	Littoral	Bays
Common Loon	FLR	FLR	FLR
Arctic Loon	FLR	FLR	FLR
Red-throated Loon	FLR	FLR	FLR
Horned Grebe		FR	F
Eared Grebe		F	F
Western Grebe		F	F
Pied-billed Grebe		X	F
Black-footed Albatross	F		
Fulmar	F	F	
Pink-footed Shearwater	FLR		
Flesh-footed Shearwater	FLR		
Sooty Shearwater	FLR	F	
Slender-billed Shearwater	FLR		
Manx Shearwater	FLR		
Fork-tailed Petrel	F		
Leach's Petrel	F		
Ashy Petrel	F		
Black Petrel	F		
Red-billed Tropicbird	F		
White Pelican		X	X
Brown Pelican	F	F	F
Double-crested Cormorant	F	F	F
Brandt's Cormorant	F	F	
Pelagic Cormorant	F	F	
Great Blue Heron		F	
Whistling Swan			X
Brant		X	X
Snow Goose			LR
Mallard			X
Pintail			X
Green-winged Teal		X	X
American Widgeon			LR
Shoveler			LR
Redhead			LR
Canvasback			LR
Greater Scaup		F	FL
Lesser Scaup		F	FL
Common Goldeneve			F
Bufflehead		F	F
Oldsquaw		F	F
White-winged Scoter		FLR	FLR
Surf Scoter		FLR	FLR
Black Scoter		FLR	FLR
Ruddy Duck		X	FLR

TABLE E5-3 CONTINUED

OCEAN

	Pelagic	Littoral	Bays
Common Merganser		F	F
Red-breasted Merganser		F	F
Osprey			F
American Coot			X
Red Phalarope	F	F	F
Wilson's Phalarope			F
Northern Phalarope	F	F	F
Pomarine Jaeger	F		F
Parasitic Jaeger	F	F	
Glaucous-winged Gull		F	F
Western Gull	X	X	
Herring Gull		X	
Thayer's Gull		X	
California Gull	X	F	F
Ring-billed Gull		X	X
Mew Gull		F	F
Bonaparte's Gull	X	F	F
Heermann's Gull	F	FL	
Black-legged Kittiwake	F	F	
Sabine's Gull	F		
Forster's Tern		F	F
Common Tern	F	F	
Arctic Tern	F		
Least Tern		F	F
Royal Tern		F	F
Elegant Tern		F	F
Caspian Tern		F	F
Common Murre	FLR	FLR	
Pigeon Guillemot	F	F	
Xantus's Murrelet	F	F	
Craveri's Murrelet	F	F	
Ancient Murrelet	F	F	
Cassin's Auklet	F	F	
Rhinoceros Auklet	F	F	
Tufted Puffin	F	F	
Belted Kingfisher			F

In addition to the species tabulated above, the following birds may use the ocean waters of the study area occasionally or irregularly; some are usually found in other habitats (see species accounts for more detail): Yellowbilled Loon, Short-tailed Albatross, Laysan Albatross, New

Zealand Shearwater, Short-tailed Shearwater, Harcourt's Petrel, Least Petrel, Wilson's Petrel, White-tailed Tropicbird, Blue-footed Booby, Brown Booby, Manificent Frigatebird, White-fronted Goose, European Widgeon, Barrow's Goldeneye, Oldsquaw, Harlequin Duck, Peregrine Falcon, Purple Gallinule, Rock Sandpiper, Long-tailed Jaeger, Skua, Glaucous Gull, Black Tern, Black Skimmer, Marbled Murrelet, Kittlitz's Murrelet, Horned Puffin.

TABLE E5-4

OCEAN SHORELINE

	Rocky Shore	Sandy Beach	Sea Cliffs
Brown Pelican	LR		NLR
Double-crested Cormorant	LR		NLR
Brandt's Cormorart	LR		NLR
Pelagic Cormorant			NLR
Surf Scoter	F		
Black Scoter	F		
Turkey Vulture	F	F	
Red-tailed Hawk			N
Peregrine Falcon	F	F	LR
American Oystercatcher	FN	F	
Black Oystercatcher	FN		
Semipalmated Plover		F	
Snowy Plover		FLRN	
Black-bellied Plover		F	
Surfbird	FLR		
Ruddy Turnstone	FLR		
Black Turnstone	FLR		
Long-billed Curlew		F	
Whimbrel	F	F	
Spotted Sandpiper	F		
Wandering Tattler	FLR		
Willet		F	
Greater Yellowlegs		F	
Knot		F	
Least Sandpiper		F	
Dunlin		F	
Short-billed Dowticher		F	
Long-billed Dowticher		F	
Western Sandpiper		F	
Marbled Godwit		F	
Sanderling		F	
Glaucous-winged Gull		FL	
Western Gull		FL	
Herring Gull		FL	
Thayer's Gull		FL	
California Gull		FL	
Ring-billed Gull		FL	
Mew Gull		FL	
Heermann's Gull		FL	
Forster's Tern		L	
Common Tern		L	
Least Tern		NLR	
Elegant Tern		L	
Caspian Tern		L	

TABLE E5-4 (CONTINUED)

OCEAN SHORELINE

	Rocky Shore	Sandy Beach	Sea Cliffs
Pigeon Guillemot	N		N
Xantus' Murrelet	N		N
Rock Dove		F	N
Ground Dove		F	
White-throated Swift			NR
Black Phoebe			N
Barn Swallow			N
Common Raven	F	F	N
Canyon Wren			FN
Rock Wren			FN
Sage Sparrow		F	

In addition to the species tabulated above, the following birds may use the ocean shoreline occasionally or irregularly, though they are usually found in other habitats (see species accounts for more detail): Common Loon, Great Blue Heron, Oldsquaw, Harlequin Duck, Bald Eagle, Prairie Falcon, Wilson's Plover, American Golden Plover, Piping Plover, Baird's Sandpiper, Stilt Sandpiper, Buffbreasted Sandpiper, Red Phalarope, Laughing Gull, Franklin's Gull, Little Gull, Black Tern.

TABLE E5-5

SALT MARSHES, ESTUARIES, AND TIDAL AREAS

(SALT WATER TO BRACKISH)

	Channels & Open Water	Mud Flats	Vegetation
Eared Grebe	FLR		
Western Grebe	FLR		
Pied-billed Grebe	FLR		
White Pelican	F	LR	
Brown Pelican	F	LR	
Double-crested Cormorant	F	L	
Great Blue Heron	F		FNLR
Common Egret	F	F	F
Snowy Egret	F	F	F
Black-crowned Night Heron		F	FLR
Least Bittern			FLR
American Bittern			FLR
Whistling Swan	F	LR	
Canada Goose	F	F	F
White-fronted Goose	F		
Snow Goose	LR		F
Mallard	X	X	
Gadwall	X	X	
Pintail	X	X	
Green-winged Teal	X	X	
Blue-winged Teal	X	X	
Cinnamon Teal	X	X	
European Widgeon	X	X	
American Widgeon	X	X	
Shoveler	X	X	
Canvasback	X		
Greater Scaup	X		
Lesser Scaup	X		
Common Goldeneye	X		
Bufflehead	X		
Surf Scoter	X		
Ruddy Duck	X		
Common Merganser	X		
Red-breasted Merganser	X		
Turkey Vulture			F
White-tailed Kite			F
Red-tailed Hawk			F
Marsh Hawk			F
Osprey	F		
Peregrine Falcon		F	F
Clapper Rail		F	FLRN
Virginia Rail			FLR

TABLE E5-5 (CONTINTUED)

SALT MARSHES, ESTUARIES, AND TIDAL AREAS

	Channels & Open Water	Mud Flats	Vegetation
Sora		F	FLR
Black Rail			FLR
American Coot	X	X	X
Semipalmated Plover		X	
Killdeer		X	
Black-bellied Plover		X	X
Ruddy Turnstone		X	
Long-billed Curlew		X	X
Whimbrel		X	X
Willet		X	X
Greater Yellowlegs		X	
Lesser Yellowlegs		X	
Knot		X	
Pectoral Sandpiper			X
Least Sandpiper		X	
Dunlin		X	
Short-billed Dowitcher		X	X
Long-billed Dowitcher		X	
Western Sandpiper		X	
Marbled Godwit		X	X
Sanderling		X	
American Avocet		X	N
Black-necked Stilt		X	N
Wilson's Phalarope		F	F
Western Gull		X	
California Gull		X	
Ring-billed Gull		X	
Bonaparte's Gull	X	X	
Forster's Tern	F	LR	
Least Tern	F	L	
Royal Tern	F	LR	
Elegant Tern	F	LR	
Caspian Tern	F	LR	
Short-eared Owl		F	FR
Belted Kingfisher	F		
Long-billed Marsh Wren			X
Yellowthroat			X
Western Meadowlark			R
Savannah Sparrow			FNR

In addition to the species tabulated above, the following birds may use the tidal areas occasionally or irregularly, though they are usually found in other habitats (see species accounts for greater detail): Little Blue Heron, Reddish Egret, Louisiana Heron, Wood Stork, Roseate Spoonbill, Emperor Goose, Ross' Goose, Barrow's Goldeneye, Harlequin Duck, Hooded Merganser, Bald Eagle, Yellow Rail, American Golden Plover, Sharp-tailed Sandpiper, Baird's Sandpiper, Stilt Sandpiper, Ruff, Sharp-tailed Sparrow.

TABLE E5-6

FRESH WATER

	Rivers & Streams	Ponds & Lakes	Marshes	Shore Lines
Red-necked Grebe		X		
Eared Grebe		X		
Western Grebe		X		
Pied-billed Grebe		X	N	
White Pelican		X		
Double-crested Cormorant	F	F		
Great Blue Heron	X	X	X	X
Green Heron	X	X	X	FN
Common Egret	X	X	X	X
Snowy Egret	X	X	X	X
Black-crowned Night Heron	X	X	X	X
Least Bittern		F	FNLR	
American Bittern		X	X	
Whistling Swan	X	X		
Canada Goose		X	X	
White-fronted Goose		X	X	
Snow Goose		LR	FLR	
Mallard	X	X	X	X
Gadwall	X	X	X	
Pintail		X	X	
Green-winged Teal		X	X	
Blue-winged Teal	X	X	X	
Cinnamon Teal	F	F	FN	LR
European Widgeon	X	X		
American Widgeon	X	X	X	
Shoveler		X	X	
Redhead	F	F	N	
Ring-necked Duck	X	X		
Canvasback	X	X		
Lesser Scaup		X		
Ruddy Duck	X	X	N	
Common Merganser	X	X		
Red-breasted Merganser		X		
White-tailed Kite			F	
Marsh Hawk			F	
Osprey	F	F		
Virginia Rail			FLRN	
Sora			FLRN	
Black Rail			FLRN	
Common Gallinule		F	FLRN	
American Coot	F	F		
Killdeer				FLRN

TABLE E5-6 (CONTINUED)

FRESH WATER

	River & Streams	Ponds & Lakes	Marshes	Shore Lines
Common Snipe			F	F
Spotted Sandpiper				F
Greater Yellowlegs				F
Lesser Yellowlegs			F	F
Solitary Sandpiper	F	F		
Least Sandpiper				F
Dunlin				F
Short-billed Dowitcher				F
Long-billed Dowitcher				F
Western Sandpiper				F
Marbled Godwit				F
American Avocet		F		FN
Black-necked Stilt		F		FN
Wilson's Phalarope		F	F	
Northern Phalarope		F		
Ring-billed Gull	X	X		
Bonaparte's Gull	X	X		
Forster's Tern		F		
Least Tern		F		
Caspian Tern		F		
Black Tern		F	F	
Short-eared Owl			F	
Belted Kingfisher	F	F		
Black Phoebe	F	F		FN
Barn Swallow	F	F		FN
Long-billed Marsh Wren			FLRN	
Yellowthroat			FLRN	F
Yellow-headed Blackbird			FN	F
Red-winged Blackbird			FN	F
Tri-colored Blackbird			FN	F

In addition to the species tabulated above, the following may use the fresh-water areas occasionally or irregularly, though they are usually found in other habitats (see species accounts for more detail): Common Loon, Horned Grebe, Yellow-crowned Night Heron, Wood Stork, White-faced Ibis, Roseate Spoonbill, Ross' Goose, Fulvous Tree Duck, Wood Duck, Greater Scaup, Hooded Merganser, Yellow Rail, Baird's Sandpiper, Water Pipit, Red-throated Pipit, Brewer's Blackbird.

TABLE E5-7

DRY LAND

	Dense Woodland	Open Woodland	Riparian	Chaparral	Brush	Grass & Arid Open Areas
Cattle Egret						F
Canada Goose						F
White-fronted Goose						F
Snow Goose						
Turkey Vulture		F		F	F	F
White-tailed Kite			NLR			
Sharp-shinned Hawk	X	X	X	X		
Cooper's Hawk	X	X	X			
Red-tailed Hawk				F	F	F
Red-shouldered Hawk		F	FN			
Rough-legged Hawk						F
Golden Eagle		F		F	F	F
Marsh Hawk					F	F
Prairie Falcon					F	F
American Kestrel		FN	FN		F	F
California Quail			X	X	X	
Ring-necked Pheasant					F	F
American Coot						F
Killdeer						FN
Mountain Plover						F
Long-billed Curlew						F
Mourning Dove		FN	FN	FN	F	F
Roadrunner					X	X
Barn Owl		FNR	FNR		F	F
Screech Owl		FNR	FNR			
Great Horned Owl			FNR	F	F	F

TABLE E5-7 (CONTINUED)

DRY LAND

	Dense Woodland	Open Woodland	Riparian	Chaparral	Brush	Grass & Arid Open Areas
Long-eared Owl		FRN	FN			
Short-eared Owl			F			FR
Burrowing Owl					F	FNR
Poor-will				F	F	
Black-chinned Hummingbird		FN	FN	F		
Costa's Hummingbird					FN	F
Anna's Hummingbird		FN	F	F	FN	
Allen's Hummingbird		FN	F	FN	F	
Common Flicker	FN	FN	FN	F	F	F
Acorn Woodpecker		FN	FN			
Yellow-bellied Sapsucker		X	X			
Downy Woodpecker		X	X			
Nuttall's Woodpecker			X			
Western Kingbird			X		X	X
Cassin's Kingbird			X		X	X
Ash-throated Flycatcher		X	X		X	
Black Phoebe			X			
Say's Phoebe					X	X
Willow Flycatcher		X	X			
Western Flycatcher		X	X			
Western Wood Pewee		X	X			
Horned Lark			X			
Rough-winged Swallow					X	X
Scrub Jay		X	X	X		
Common Raven		X	X	X	X	X
Common Crow		X	X	X	X	X

TABLE E5-7 (CONTINUED)

DRY LAND

	Dense Woodland	Open Woodland	Riparian	Chaparral	Brush	Grass & Arid Open Areas
Plain Titmouse		X	X			
Common Bushtit		X	X	X		
White-breasted Nuthatch	X	X				
Red-breasted Nuthatch	X	X				
Wrentit			X	X	X	
House Wren		X	X			
Bewick's Wren		X	X	X	X	
Cactus Wren				X	X	
Mockingbird		X	X	X	X	
California Thrasher		X	X	X		
Robin		X	X			
Varied Thrush		X	X			
Hermit Thrush		X	X	X		
Swainson's Thrush			FN			
Western Bluebird		FN				F
Moutain Bluebird						X
Blue-gray Gnatcatcher			X	X		
Black-tailed Gnatcatcher					X	
Golden-crowned Kinglet	X	X				
Ruby-crowned Kinglet	X	X	X	X	X	
Water Pipit						X
Cedar Waxwing	X	X	X			
Phainopepla			X		X	
Loggerhead Shrike			X		X	X
Starling		X	X		X	X
Hutton's Vireo		X	X			

TABLE E5-7 (CONTINUED)

DRY LAND

	Dense Woodland	Open Woodland	Riparian	Chaparral	Brush	Grass & Arid Open Areas
Bell's Vireo			X			
Warbling Vireo		X	X			
Orange-crowned Warbler		X	X	X	X	
Yellow Warbler		X	X			
Yellow-rumped Warbler		X	X	X	X	
Black-throated Gray Warbler	X	X	X	X		
Townsend's Warbler		X	X			
Hermit Warbler		X	X			
Yellowthroat			X			
Yellow-breasted Chat			X			
Wilson's Warbler			X			
House Sparrow		X				
Western Meadowlark					X	X
Hooded Oriole		X	X			
Northern Oriole		X	X			
Brown-headed Cowbird		X	X	X		X
Black-headed Grosbeck		X	X			
Blue Grosbeck			X		X	
Lazuli Bunting			X		X	
Purple Finch	X	X				
Cassin's Finch	X	X				
House Finch		X	X	X	X	X
Pine Siskin	X	X				
American Goldfinch		X	X			X
Lesser Goldfinch			X	X		

TABLE E5-7 (CONTINUED)

DRY LAND

	Dense Woodland	Open Woodland	Riparian	Chaparral	Brush	Grass & Arid Open Areas
Lawrence's Goldfinch		X		X	X	X
Red Crossbill	X	X				
Rufous-sided Towhee		X	X	X	X	
Brown Towhee			X	X	X	
Savannah Sparrow						X
Grasshopper Sparrow						X
Vesper Sparrow						X
Lark Sparrow						X
Rufous-crowned Sparrow				X	X	
Sage Sparrow					X	X
Dark-eyed Junco		X	X	X	X	
Chipping Sparrow		X			X	X
Black-chinned Sparrow				X	X	
White-crowned Sparrow		X	X	X	X	
Golden-crowned Sparrow		X	X	X	X	
Fox Sparrow		X	X	X		
Lincoln's Sparrow					X	
Song Sparrow			X		X	

In addition to the species tabulated above, the following birds may use the dry land habitats occasionally or irregulary, though, they are usually found elsewhere (see species accounts for greater detail): Ross' Goose, Broad-winged Hawk, Swainson's Hawk, Ferruginous Hawk, Bald Eagle, Peregrine

TABLE E5-7 (CONTINUED) DRY LAND

Falcon, Pigeon Hawk, Common Peafowl, Band-tailed Pigeon, White-winged Dove, Spotted Dove, Ringed Turtle Dove, Saw-whet Owl, Whip-poor-will, Lesser Nighthawk, Chimney Swift, Black Swift, Vaux's Swift, Rufous Hummingbird, Calliope Hummingbird, Lewis' Woodpecker, Williamson's Sapsucker, Hairy Woodpecker, Tropical Kingbird, Hammond's Flycatcher, Dusky Flycatcher, Gray Flycatcher, Purple Martin, Violet-green Swallow, Tree Swallow, Bank Swallow, Sage Thrasher, Solitary Vireo, Tennessee Warbler, Nashville Warbler, Northern Waterthrush, MacGillivray's Warbler, American Redstart, Western Tanager, Brewer's Sparrow.

TABLE E5-8

BIRDS OF THE CHANNEL ISLANDS

	Endemic Form	Permanent Resident	Seasonal Resident (summer-S winter-W)	Migrant or Regularly Occurring
Ashy Petrel			Sb	
Brown Pelican		rb		
Double-crested Cormorant		rb		
Brandt's Cormorant		rb		
Pelagic Cormorant		rb		
Great Blue Heron		r		
Snow Goose				X
Surf Scooter			W	
Red-breasted Merganser			W	
Cooper's Hawk		rb		
Red-tailed Hawk		rb		
American Kestrel		rb		
California Quail	e			
Gambel's Quail		rb		
Chukar		rb		
Common Peafowl		rb		
American Coot		rb		
American Oystercatcher		rb		
Blacky Oystercatcher		rb		
Semipalmated Plover			W	
Snowy Plover		rb		
Killdeer		rb		
Ruddy Turnstone			W	
Black-bellied Plover			W	
Black Turnstone			W	
Long-billed Curlew			W	
Whimbrel			W	
Spotted Sandpiper			W	
Wandering Tattler			W	
Willet			W	
Least Sandpiper			W	
Dunlin			W	
Western Sandpiper			W	
Marbled Godwit			W	
Sanderling			W	
Glaucous-winged Gull			W	
Western Gull			Sb	
Herring Gull			W	
Thayer's Gull			W	
California Gull			W	
Ring-billed Gull			W	

TABLE E5-8 (CONTINUED)

BIRDS OF THE CHANNEL ISLANDS

	Endemic Form	Permanent Resident	Seasonal Resident (summer-S winter-W)	Migrant or Regularly Occurring
Mew Gull			W	
Heermann's Gull			W	
Royal Tern		r		
Pigeon Guillemot			Sb	
Xantus' Murrelet			Sb	
Rock Dove		rb		
Mourning Dove		rb		
Barn Owl		rb		
Burrowing Owl		rb		
Saw-whet Owl		rb		
White-throated Swift		rb		
Costa's Hummingbird		rb		
Anna's Hummingbird		rb		
Allen's Hummingbird	e			
Kingfisher		r		
Common Flicker		rb		
Acorn Woodpecker		rb		
Yellow-bellied Sapsucker			W	
Western Kingbird				X
Cassin's Kingbird				X
Ash-throated Flycatcher				X
Black Phoebe		rb		
Say's Phoebe			W	
Willow Flycatcher				X
Hammond's Flycatcher				X
Western Flycatcher	e			
Western Wood Pewee				X
Horned Lark	e			
Barn Swallow			Sb	
Scrub Jay	e			
Common Raven		rb		
Common Bushtit		rb		
Red-breasted Nuthatch		rb		
Bewick's Wren	e			
Rock Wren		rb		
Mockingbird		rb		
Sage Thrasher				X
Robin			Sb	
Varied Thrush			W	
Hermit Thrush			W	
Blue-gray Gnatcatcher		rb		

TABLE E5-8 (CONTINUED)

BIRDS OF THE CHANNEL ISLANDS

	Endemic Form	Permanent Resident	Seasonal Resident (summer-S winter-W)	Migrant or Regularly Occurring
Ruby-crowned Kinglet			W	
Water Pipit			W	
Cedar Waxwing			W	
Loggerhead Shrike	e			
Starling		rb		
Hutton's Vireo		rb		
Warbling Vireo				X
Orange-crowned Warbler	e			
Yellow Warbler				X
Yellow-rumped Warbler			W	
Townsend's Warbler				X
Wilson's Warbler				X
House Sparrow		rb		
Western Meadowlark		rb		
Yellow-headed Blackbird				X
Red-winged Blackbird		rb		
Hooded Oriole			Sb	
Brewer's Blackbird				X
Brown-headed Cowbird		r		
Western Tanager				X
Purple Finch			W	
House Finch	e			
Lesser Goldfinch		rb		
Lawrence's Goldfinch		r		
Rufous-sided Towhee	e			
Savannah Sparrow			W	
Rufous-crowned Sparrow	e			
Sage Sparrow	e			
Dark-eyed Junco			W	
Chipping Sparrow			W&Sb	
Brewer's Sparrow				X
White-crowned Sparrow			W	
Golden-crowned Sparrow			W	
Fox Sparrow			W	
Lincoln's Sparrow			W	
Song Sparrow	e			

In addition to the species in Table II-6H, the following birds have been recorded on or near the islands. Some of these may in fact be resident there; insufficient research has been done to be certain. Common

Table E5-8 (Continued)

Loon, Arctic Loon, Red-throated Loon, Horned Grebe, Eared Grebe, Western Grebe, Pied-billed Grebe, Black-footed Albatross, Laysan Albatross, Fulmar, Pink-footed Shearwater, Sooty Shearwater, Manx Shearwater, Black Petrel, Red-billed Tropicbird, Blue-footed Booby, Brown Booby, Green Hermon, Common Egret, Snowy Egret, Black-crowned Night Heron, White-faced Ibis, Canada Goose, Brant, White-fronted Goose, Mallard, Pintail, Green-winged Teal, Blue-winged Teal, Cinnamon Teal, American Widgeon, Lesser Scaup, Bufflehead, Harlequin Duck, White-winged Scoter, Common Scoter, Ruddy Duck, Turkey Vulture, Sharp-shinned Hawk, Swainsun's Hawk, Golden Eagle, Bald Eagle, Marsh Hawk, Osprey, Peregrine Falcon, Ring-necked Pheasant, Virginia Rail, Sora, Mountain Plover, American Golden Plover, Surfbird, Ruddy Turnstone, Common Snipe, Solitary Sandpiper, Greater Yellowlegs, Knot, Pectoral Sandpiper, Baird's Sandpiper, Short-billed Dowitcher, Long-billed Dowitcher, American Avocet, Black-necked Stilt, Red Phalarope, Wilson's Phalarope, Northern Phalarope, Pomarine Jaeger, Parasitic Jaeger, Claucous Gull, Franklin's Gull, Bonaparte's Gull, Black-legged Kittiwake, Sabine's Gull, Forster's Tern, Common Tern, Elegant Tern, Common Murre, Craveri's Murrelet, Cassin's Auklet, Rhinoceros Auklet, Tufted Puffin, Great Horned Owl, Long-eared Owl, Short-eared Owl, Poorwill, Lesser Nighthawk, Vaux's Swift, Rufous Hummingbird, Lewis's Woodpecker, Williamson's Sapsucker, Violet-green Swallow, Tree Swallow, Rough-winged Swallow, Cliff Swallow, Purple Martin, Common Crow, White-breasted Nuthatch, House Wren, Winter Wren, Long-billed Marsh Wren, Canyon Wren, Swainson's Thrush, Western Bluebird, Mountain Bluebird, Golden-crowned Kinglet, Bell's Vireo, Solitary Vireo, Tennessee Warbler,

Table E5-8 (Continued)

Nashville Warbler, Magnolia Warbler, Black-throated Gray Warbler, Hermit Warbler, Northern Waterthrush, MacGillivray's Warbler, Yellowthroat, Yellow-breasted Chat, Tri-colored Blackbird, Northern Oriole, Black-headed Grosbeak, Blue Grosbeak, Lazuli Bunting, Pine Siskin, American Goldfinch, Red Crossbill, Vesper Sparrow, Lark Sparrow, Black-chinned Sparrow, Harris's Sparrow, White-throated Sparrow.

TABLE E5-9 DILLINGHAM CORP. (1971)

BIRDS OF BOLSA CHICA

Scientific Name	Common Name
Anas acuta	Pintail
Anas cyanoptera	Cinnamon teal
Anas platyrhynchos	Mallard (duck)
Ardea herodias	Great blue heron
Arenaria interpres	Ruddy turnstone
Buteo jamaicensis	Red-tailed hawk
Butorides virescens	Green heron
Calidris canutus	Knot
Calypte anna	Anna's hummingbird
Carpodacus mexicanus	House finch
Casmerodius albus	Common egret
Cathartes aura	Turkey vulture
Catoptrophorus semipalmatus	Willet
Charadrius alexandrinus	Snowy plover
Charadrius semipalmatus	Semipalmated plover
Charadrius vociferus	Killdeer
Childonias niger	Black tern
Circus cyaneus	Marsh hawk
Colaptes cafer	Red-shafted flicker
Columbia livia	Rock dove
Corvus brachyrhynohos	Common crow
Corvus corax	Common Raven
Crocenthia alba	Sanderling

TABLE E5-9 DILLINGHAM CORP. (1971)

BIRDS OF BOLSA CHICA

Scientific Name	Common Name
Empidonax difficilis	Western flycatcher
Ereunetes mauri	Western sandpiper
Erolia alpina	Dunlin
Erolia minutilla	Least sandpiper
Euphagus cyanocephalus	Brewer's blackbird
Falco spaverius	Sparrow hawk
Fulica americana	American coot
Himantopus maxicanus	Black-necked stilt
Hirundo rustica	Barn swallow
Hydroprogne caspia	Caspian tern
Lanius ludovicianus	Loggerhead shrike
Larus delawarensis	Ring-billed gull
Larus heermanni	Heermann's gull
Larus occidentalis	Western gull
Laurs Philadelphia	Bonaparte's gull
Leucophoyx thula	Snowy egret
Limnodromus griseus	Short-billed dowitcher
Limosa fedoa	Marbled godwit
Lobipes lobatus	Northern phalarope
Lophortyx californicus	California quail
Mareca americana	American Widgeon
Megaceryle alcyon	Belted kingfisher
Melospiza melodia	Song sparrow

TABLE E5-9 DILLINGHAM CORP. (1971)

BIRDS OF BOLSA CHICA

Scientific Name	Common Name
Micropalama himantopus	Stilt sandpiper
Numenius americanus	Long-billed curlew
Numenius phaeopus	Whimbrel
Oxyura jamaicensis	Ruddy duck
Passerculus sandwichensis	Savannah sparrow
Pelecanus occidentalis	Brown pelican
Pertrochelidon pyrrhonota	Cliff swallow
Pipilo fascus	Brown towhee
Podicaps caspicus	Eared grebe
Podilymbus podiceps	Pied-billed grebe
Recurvirostra americana	American avocet
Sayornis nigricans	Black phoebe
Spatula cypeata	Shoveller
Speotyto cunicularia	Burrowing owl
Spinus psaltria	Lesser goldfinch
Squatarola squatarola	Black-bellied plover
Streganopus tricolor	Wilson's phalarope
Sterna forsteri	Forster's tern
Sterna hirundo	Common tern
Sturnella neglecta	Western meadowlark
Sturnus vulgaris	Starling
Telmatodytes palustris	Long-billed marsh wren
Thalasseus elegans	Elegant tern
Totanus flavipes	Lesser yellowlegs

TABLE E5-9 DILLINGHAM CORP. (1971)

BIRDS OF BOLSA CHICA

Scientific Name	Commom Name
Tontanus melanoleucus	Greater yellowlegs
Tringa solitaria	Solitary sandpiper
Tyrannus verticalis	Western kingbird
Zenaidura macroura	Mourning dove
Zonotrichia atricapilla	Golden-crowned sparrow
Zonotrichia leucophrys	White-crowned sparrow

TABLE E5-10 DILLINGHAM CORP. (1971)

FIFTEEN MOST ABUNDANT WATER-BIRD SPECIES ON THE FIVE CENSUSES

Species	23 June	11 August	3 September	19 September	10 October	Totals
Northern phalarope (NP)	0	1415	765	680	131	2991
Western sandpiper (WSP)	0	320	265	1153	452	2190
Willet (WIL)	8	276	195	417	748	1636
Black-bellied plover (BBP)	0	262	87	220	270	839
Ring-billed gull (RBG)	33	247	297	39	87	703
Black-necked stilt (BNS)	106	64	102	207	108	587
Wilson's phalarope (WP)	145	312	101	22	0	580
Common tern (CT)	0	27	375	150	3	555
Sanderling (SAN)	0	141	9	0	207	357
Marbled godwit (MG)	42	41	10	43	137	273
Short-billed dowitcher (DOW)	0	5	14	82	151	252
Elegant tern (ET)	0	8	216	16	3	243
Avocet (AVO)	85	18	45	64	12	224
Least sandpiper (LSP)	0	23	0	105	56	184
Killdeer (KIL)	24	28	20	30	31	133
TOTALS	435	3187	2501	3228	2396	11,747

REFERENCES

Ahlstrom, E. H. 1959. Vertical distribution of pelagic fish eggs and larvae off California and Baja, California. U. S. Fish and Wildlife Service, Fish. Bull. 161 (60): 107-143.

______________. 1960. Synopsis on the biology of the Pacific Sardine *(Sardinops caerulea)*. Proc. World Sci. Meet. Biol. Sardines and Related Species. FAO, Rome, 2: 415-451.

______________. 1965. Kinds and abundance of fishes in the California Current region based on egg and larval surveys. Calif. Coop. Oceanic Fish. Invest. Rept. 10: 31-52.

______________. 1967. Co-occurrences of sardine and anchovy larvae in the California Current region off California and Baja, California. Calif. Coop. Oceanic Fish. Invest. Rept. 11: 117-135.

______________. 1969. Mesopelagic and bathypelagic fishes in the California Current region. Calif. Coop. Oceanic Fish. Invest. Rept. 13: 39-44.

______________ and O. P. Ball. 1954. Description of eggs and larvae of jack mackerel (*Traehurus symmetricus*) and the distribution and abundance of larvae in 1950 and 1951. U. S. Fish. Wildl. Ser., Fish. Bull. 56: 209-245.

______________ and R. C. Counts. 1955. Eggs and larvae of the Pacific hake *Merluccius productus*. U. S. Fish Wildl. Ser., Fish. Bull. 56: 295-329.

______________________________. 1958. Development and distribution of *Vinciguerria lucetia* and related species in the Eastern Pacific. U. S. Fish. Wildl. Ser., Fish. Bull. 58: 363-416.

Allan Hancock Foundation. 1965. An oceanographic and biological survey of the Southern California mainland shelf. Calif. State Water Quality Control Board Publ. No. 27., 232 p.

Allanson, A. 1955. Sea otters on San Miguel. Pacific Discovery 8: 24-25.

Allen, J. A. 1970. History of North American Pinnipeds. Washington, U. S. Geol. Geogr. Survey Terr., Misc. Publ. 12: xvi + 785 pp.

Allen, W. E. 1921a. Preliminary statistical studies of marine phytoplankton of the San Diego region, California. Spec. Publ. Bernice Bishop Mus. 7: 537-554.

__________. 1921b. Some work on marine phytoplankton in 1919. Trans. Amer. Microscop. Soc. 40: 177-181.

__________. 1922a. Quantitative studies on marine phytoplankton at La Jolla in 1919. Univ. Calif. Publ. Zool. 22: 329-347.

__________. 1922b. Quantitative studies on inshore marine diatoms and dinoflagellates of Southern California in 1920. Univ. Calif. Publ. Zool. 22: 369-378.

__________. 1923a. Studies on catches of marine phytoplankton made by aid of the Kofoid bucket in 1921. Ecology 4: 74-80.

__________. 1923b. Some tide-water collections of marine diatoms taken at half-hour intervals near San Diego, California. Univ. Calif. Publ. Zool. 22: 413-416.

__________. 1923c. Studies on marine diatoms and dinoflagellates caught by aid of the Kofoid bucket in 1922. Univ. Calif. Publ. Zool. 22: 435-445.

__________. 1923d. Recent work on marine micro-plankton at the La Jolla biological station. Trans. Amer. Microscop. Soc. 42: 180-183.

__________. 1923e. Statistical studies of marine diatoms of the San Diego region collected by U. S. S. Pioneer in midwinter 1923. Univ. Calif. Publ. Zool. 22: 445-448.

__________. 1923f. Observations on surface distribution of marine diatoms of Lower California in 1921. Proc. Calif. Acad. Sci. 12: 473-442.

__________. 1924a. Surface catches of marine diatoms and dinoflagellates made by U. S. S. Pioneer between San Diego and Seattle in 1923. Univ. Calif. Publ. Zool. 26: 243-248.

__________. 1924b. Observations on surface distribution of marine diatoms of Lower California in 1922. Ecology 5: 389-392.

__________. 1926. Remarks on surface distribution of marine plankton diatoms in the east Pacific. Science 63: 96-97.

__________. 1927a. Quantitative studies on inshore marine diatoms and dinoflagellates of Southern California in 1921. Bull. Scripps Inst. Oceanogr., Tech. Ser., 1: 19-29.

__________. 1927b. Quantitative studies on inshore marine diatoms and dinoflagellates of Southern California in 1922. Bull. Scripps Inst. Oceanogr., Tech. Ser., 1: 31-38.

__________. 1927c. Surface catches of marine diatoms and dinoflagellates made by U. S. S. Pioneer in Alaskan waters in 1923. Bull. Scripps Inst. Oceanogr., Tech. Ser., 1: 39-48.

__________. 1927d. Effect of tidal changes on physical, chemical, and biological conditions in seawater of the San Diego region. II. Half-hourly collections of marine microplankton taken at the Scripps Institution pier in 1923. Bull. Scripps Inst. Oceanogr., Tech. Ser., 1: 15-17.

__________. 1928a. Catches of marine diatoms and dinoflagellates taken by boat in Southern California waters in 1926. Bull. Scripps Inst. Oceanogr., Tech. Ser., 1: 201-245.

__________. 1928b. Quantitative studies of inshore marine diatoms and dinoflagellates collected in Southern California in 1924. Bull. Scripps Inst., Oceanogr. Tech. Ser., 1: 347-356.

__________. 1928c. Review of five years of studies on phytoplankton at Southern California piers, 1920-1924 inclusive. Bull. Scripps Inst. Oceanogr., Tech. Ser., 1: 357-401.

__________. 1929a. Surface catches of marine diatoms and dinoflagellates made by U. S. S. Pioneer in Alaskan waters in 1924. Bull. Scripps Inst. Oceanogr., Tech. Ser., 2: 139-153.

__________. 1929b. Ten years of statistical studies of marine phytoplankton at the Scripps Institution of Oceanography. Science 70: 416-419.

__________. 1930a. Quantitative studies of surface catches of marine diatoms and dinoflagellates taken in Alaskan waters by the International Fisheries Commission in the fall and winter of 1927-1928 and 1929. Bull. Scripps Inst. Oceanogr., Tech. Ser. 2: 389-399.

__________. 1930b. Methods in quantitative research on marine microplankton. Bull. Scripps Inst. Oceanogr. Tech. Ser. 2: 319-329.

__________. 1933a. Boat catches of marine phytoplankton in Southern California in 1928. Amer. Jour. Bot. 21: 66-68.

__________. 1933b. Surface phytoplankton obtained by the Templeton Crocker expedition of the California Academy of Sciences of 1932. Trans. Amer. Microscop. Soc. 52: 101-102.

__________. 1933c. Red water in La Jolla Bay in 1933. Science 78: 12-13.

__________. 1934. Marine plankton diatoms of Lower California in 1931. Bot. Gaz. 95: 485-492.

__________. 1935. Yellow water in La Jolla Bay in 1935. Science 82: 325-326.

__________. 1936. Occurrence of marine plankton diatoms in a ten-year series of daily catches in Southern California. Amer. Jour. Bot. 23: 60-63.

__________. 1937. Plankton diatoms of the Gulf of California obtained by the G. Allan Hancock expedition of 1936. Univ. South. Calif. Press, Hancock Pacific Exped. 3: 47-59.

__________. 1938a. The Templeton Crocker expedition to the Gulf of California in 1935-the phytoplankton. Trans. Amer. Microscop. Soc. 57: 328-335.

__________. 1938b. Red water along the west coast of the United States in 1938. Science 88: 55-56.

__________. 1939. Surface distribution of marine plankton diatoms in the Panama region in 1933. Bull. Scripps Inst. Oceanogr. Tech. Ser. 4: 181-196.

__________. 1940a. Methods and laboratory procedure in phytoplankton research of the Scripps Institution of Oceanography of the University of California. Scripps Inst. Oceanogr. Contr., New Ser. 101: 525-528.

__________. 1940b. Discolored sea water, Hydrogr. Bull., No. 2662, U. S. Hydrographic Office, Washington, D. C.

__________. 1940c. Summary of results of twenty years of researches on marine phytoplankton. Contr. Scripps Inst. Oceanogr., New Ser., 102: 577-583.

__________. 1941. Twenty years statistical studies of marine plankton dinoflagellates of Southern California Amer. Midland Natur. 26: 603-635.

__________. 1942. Occurrence of red water near San Diego. Science 96: 471.

__________. 1943. Red water in La Jolla Bay in 1942. Trans Amer. Microscop. Soc. 62: 262-264.

__________. 1945a. Occurrences and abundances of plankton diatoms offshore in Southern California. Trans. Amer. Microscop. Soc. 64: 21-24.

__________. 1945b. Seasonal occurrences of marine plankton diatoms off Southern California in 1938. Bull. Scripps Inst. Oceanogr. 5: 293-334.

__________. 1945c. Vertical distribution of marine plankton diatoms offshore in Southern California in 1940. Bull. Scripps Inst. Oceanogr. 5: 335-370.

__________. 1946. Red water in La Jolla Bay in 1945. Trans. Amer. Microscop. Soc. 65: 149-153.

__________ and R. Lewis. 1927. Surface catches of marine diatoms and dinoflagellates from Pacific high seas in 1925 and 1926. Bull. Scripps Inst. Oceanogr., Tech. Ser. 1: 197-200.

Alvarino, A. 1965. Distributional atlas of Chaetognatha in the California Current region. CalCOFI Atlas No. 3: 1-291.

__________. 1967. Bathymetric distribution of Chaetognatha, Siphonophorae, medusae, and Ctenophorae off San Diego, California. Pac. Sci. 21(4): 474-485.

Alverson, D. L. and H. A. Larkins. 1969. Status of knowledge of the Pacific hake resource. Calif. Marine Research Comm., Calif. Cooperative Oceanic Fisheries Investigations. 13: 24-31.

American Ornithologists" Union. 1957. Check-list of North American Birds: 5th ed., Am. Ornith. Union, 691 p.

Anas, R. E. and A. J. Wilson. 1970a. Residues in fish, wildlife and estuaries. Organochlorine pesticides in fur seals. Pestic. Monit. J. 3: 198-200.

______________________________. 1970b. Organochlorine pesticides in nursing fur seal pups. Pestic. Monit. J. 4: 114-116.

Anderson, A. M., E. Diamantopoulos and C. B. B. Downman. 1960. Auditory cortex of the seal (*Phoca vitulina*). J. Anat. 94: 506-511.

Anderson, S. and J. K. Jones. 1967. Recent mammals of the world. A synopsis of families. Ronald Press Co., N. Y. 453 pp.

Annual Report, Kelp Habitat Improvement Project. 1971-72. Calif. Inst. Tech., 200 pp.

Anonymous. 1969. Fish and wildlife management plan. U. S. Naval Weapons Station, Seal Beach, California, 31 p. (In Dillingham Corp., 1971).

Atstatt, L. H., and R. R. Seapy. 1974. An analysis of sampling variability in replicated midwater trawls off Southern California. J. Exp. Mar. Biol. Ecol: in press.

Bable, J. S. 1967. Reproduction, life history and ecology of the round stingray, *Urolophus balleri*. Cooper. Calif. Dept. Fish Game Fish Bull. 132.

Backhouse, K. M. 1961. Locomotion of seals with particular reference to the prelimb. Symp. Zool. Soc. Lond. (5): 59-75.

Bakus, G. J. 1966. Marine poeciloscleridan sponges of the San Juan Archipelago, Washington, J. Zool., Lond., 149: 415-531.

Balech, E. 1960. The changes in the phytoplankton population off the California coast. Calif. Mar. Res. Comm. CalCOFI Rept. 7: 127-132.

Barnett, C. H., R. J. Harrison and J. D. W. Tomlinson. 1958. Variations in the venous systems of mammals. Biol. Rev. 33: 242-287.

Bartholomew, G. A. 1950. A male Guadalupe fur seal on San Nicolas Island, California. J. Mamma. 31: 175-180.

________________. 1951. Spring, summer and fall census of the pinnipeds on San Nicolas Island, California. J. Mamma. 32: 15-21.

________________. 1952. Reproductive and social behavior of the Northern Elephant Sea. Univ. Calif., Publ. Zool. 47(15): 369-472.

________________. 1959. Mother-young relations and the maturation of pup behavior in the Alaska fur sea. Animal Behaviour 7: 163-171.

________________. 1967. Seal and sea lion populations of the California Islands. Proc. Symp. Biol. Calif. Islands, Santa Barbara Botanic Garden, pp. 229-234.

________________. 1970. A model for the evolution of pinniped polygyny. Evolution 24(3): 546-559.

________________ and C. L. Hubbs. 1952. Winter populations of pinnipeds about Guadalupe, San Benito and Cedros Islands, Baja, California. J. Mamma. 33: 160-171.

________________ and P. G. Hoel. 1953. Reproductive behavior of the Alaska fur seal, *Callorhinus ursinus*. J. Mamm. 34(4): 417-436.

________________ and F. Wilkie. 1956. Body temperature in the northern fur seal, *Callorhinus ursinus*. J. Mamm. 37(3): 327-337.

________________ and R. A. Boolootian. 1960. Numbers and population structure of the pinnipeds on the California Channel Islands. J. Mamm. 41(3): 366-375.

________________ and C. L. Hubbs. 1960. Population growth and seasonal movements of the Northern Elephant seal, *Mirounga angustirostris*. Mammalia, Paris, 24: 313-324.

Batzli, G. O. 1969. Distribution of biomass in rocky intertidal communities on the Pacific Coast of the United States. J. Animal Ecology 38: 531-546.

Baxter, J. L. 1967. Summary of biological information on the northern anchovy, *Engraulis mordax* Girard. Calif. Mar. Res. Comm. Calif. Coop. Oceanic Fish. Invest. Rept. 11: 110-116.

____________ and staff. 1960. A study of the yellowtail. Calif. Dept. Fish Game Fish Bull. 110: 1-91.

Bender, K. E., C. T. Collins and S. L. Warter. 1974. Marine and shore birds. In a summary of knowledge of the Southern California coastal zone and offshore area. Vol. 3, Southern California Ocean Studies Consortium Long Beach, 169 p.

Bernard, J. L. 1962. Benthic marine exploration of Bahia de San Quintin, Baja, California, 1960-61. General. Pacific Nat. 3: 249-274.

____________. 1963. Relationships of benthic amphipoda to invertebrate communities of inshore sublittoral sands of Southern California. Pac. Nat., 3(15): 439-468.

____________. 1965. Marine Amphipoda of the family Ampithoidae from So. Calif. Proc. of U. S. Nat'l. Mus. 118 (3522): 1-46.

____________. 1969a. The families and genera of marine Gammaridean Amphipoda. U. S. Nat'l. Mus., Bull. 271: 1-535.

____________. 1969b. Gammaridean Amphipoda of the Rocky Intertidal of Calif.: Monterey Bay to LaJolla. Smithsonian Institution, U. S. Nat. Mus., Wash. D. C., Bull. 258.

____________. 1972. A review of the family Synopiidea (=Tironidae) mainly distributed in the deep sea (Crustacea: Amphipoda Smithsonian Cont. to Zool. No. 124 Smithsonian Inst. Press.

____________, Boolootian & Leighton. 1966. A key to the species of Ophiuroidea (Brittle stars) of the Santa Monica Bay and adjacent areas. LACM, Contrib. Sci. 93: 1-20.

____________ and R. R. Given. 1960a. Morphology and ecology of some sublittoral Cumacean Crustacea of Southern California. Pac. Naturalist. 2(3): 153-165.

_______________________. 1960b. Common pleustid Amphipods of So. Calif. with a projected revision of the family. Pac. Naturalist. 1(17): 37-48.

____________ and Olga Hartman. 1959. The sea bottom off Santa Barbara, California: biomass and community structure. Pac. Natural., (6): 1-16.

__________, Olga Hartman, and G. F. Jones. 1959. Benthic biology of the mainland shelf of Southern California. In oceanographic survey of the continental shelf area of Southern California, California State Water Poll. Control Bd. Publ. 20. p. 265-429.

__________ and F. C. Ziesenhenne. 1961. Ophiuroid communities of So. Calif. coastal bottoms. Pac. Naturalist. 2(2): 131-152.

Berner, L. D. 1967. Distributional atlas of Thaliacea in the California Current region. CalCOFI Atlas No. 8: 1-322.

__________ and J. L. Reid, Jr. 1961. On the response to changing temperature of the temperature-limited plankter *Doliolum denticulatum* Quoy and Gaimard: 1835. Limnol. Oceanogr., 6(2): 205-215.

Berry, F. H. and H. C. Perkins. 1965. Survey of pelagic fishes of the California Current area. U. S. Fish. Wildl. Ser., Fish. Bull. 65(3): 625-682.

Boney, A. D. 1965. Aspects of the biology of seaweeds of economic importance. Adv. mar. Biol., 3, 105-235.

Bonnat, P. and W. E. Ripley. 1948. The California sea lion census for 1947. Calif. Fish and Game 34: 89-92.

Bookhout, C. G. and J. D. Costlow, Jr. 1970. Nutritional effect of Artemia from different locations on larval development of crabs. *Helgolander Wissen. Meeresunters*. 20: 435-41.

Boolootian, R. A. 1961. The distribution of the California sea otter. Calif. Fish and Game 47(3): 287-292.

Bowman, T. E. 1953. The systematics and distribution of pelagic Amphipoda of the families Vibiliidae, Paraphronimidae, Hyperiidae, Dairellidae, and Phrosinidae from the Northern Eastern Pacific. Ph. D. thesis, University of California, Los Angeles.

__________. 1973. Pelagic amphipods of the genus *Hyperia* and closely related genera (Hyperiidea: Hyperiidae). Smithsonian Contrib. Zool. 136: 1-76.

Bright, D. B. 1974. Benthic invertebrates of the Southern California coastal zone and offshore areas. Southern California Ocean Studies Consortium.

Brinton, E. 1967. Distributional atlas of Euphausiacea (Crustacea) in the California Current region, Part I. CalCOFI Atlas No. 5: 1-275.

Brongersma-Sanders, M. 1957. Mass mortality in the sea. In J. W. Hedgpeth (ed.), Treatise on marine ecology and paleoecology. Vol. 1, Amer. Geol. Soc. Me. 67: 941-1011.

Brown, D. H. and K. S. Norris. 1956. Observations of captive and wild cetaceans. J. Mamm. 37(3): 311-326.

Brown, D. W. 1969. Midwater-fish communities of three contiguous oceanic environments. Ph. D. thesis, University of California, Santa Barbara.

Brown, Richard, Alvin W. Smith and Mark C. Keyes. 1974. Sarcocystis in the Northern Fur Seal. J. Wildl. Dis. 10: 53.

Brownell, R. L. and B. J. LeBoeuf. 1971. California sea lion mortality: natural or artifact. In D. Straugh (ed.), Biological and oceanographical survey of the Santa Barbara oil spill 1969-1970, Vol. 1, Biology and bacteriology, pp. 287-306, Allan Hancock Foundation, University of Southern California.

Brusca, G. J. 1967. The ecology of pelagic Amphipoda. I. Species accounts, vertical zonation and migration of Amphipoda from the waters off Southern California. Pac. Sci. 21: 382-393.

Bryan, G. W. 1971. The effects of heavy metals (other than mercury) on marine and estuarine organisms. Proc. Roy. Soc. London Ser. B. 177: 389-410.

Bullivant, J. S. 1970. A note on the hydroid Dipurena reesi Vannucci and medusae of the genus Cladonema collected together near Los Angeles. Bull. So. Cal. Acad. Sci., 69(2): 112-114.

Burch, J. 1944-46. Distributional list of the West American marine Mollusca from San Diego, California, to the Polar Sea. Extracts from the Minutes of the Conchological Club of Southern California, pt. I (Pelecypoda), nos. 33-45 (Mar. 1944-Feb. 1945); pt. II, vols. I & II (Gastropoda), nos. 46-63 (Mar. 1945-Sept. 1946).

Bureau of Sport Fisheries and Wildlife. 1973. Threatened wildlife of the United States. 289 p.

Burnett, R. 1971. DDT residues: Distribution of concentrations in *Emerita analoga* (Stimpson) along coastal California. Science 174: 606-608.

Butler, P. A. 1966. Fixation of DDT in estuaries. In Transactions of the 31st North American Wildlife and Natural Resources Conference, pp. 184-9. Washington, D. C.: Wildlife Mgmt. Inst.

California Department of Fish and Game. 1969. Progress report on wildlife affected by the Santa Barbara Channel oil spill. January 28-March 31, 1969. (In Straughan, 1971 and U. S. Geological Survey, 1973).

____. 1973. Coastal County Fish and Wildlife resources and their utilization. 258 pages, August 1973. Sacramento, California.

Caplan, R. and R. Boolootian. 1967. Intertidal ecology of San Nicolas Island. In Proceedings of the Symposium on the Biology of California Islands. Santa Barbara Bot. Grd., California: 203-217.

Carlisle, J. G. 1968. Red tide in California. State Calif. Dept. Fish and Game Mar. Res. Leaf. No. 2, Sacramento. 6 p.

______________. 1969. Results of a six-year trawl study in an area of heavy waste discharge: Santa Monica Bay, California. Calif. Fish and Game, 55(1): 26-46.

______________. 1973. The census of northern elephant seals on San Miguel Island, 1965-1973. Calif. Dept. Fish and Game, 59: 311-313.

______________ and J. A. Aplin. 1971. Sea lion census for 1970, including counts of other California pinnipeds. Calif. Dept. Fish and Game 57(2): 124-126.

______________, J. W. Schott and N. J. Abramson. 1960. The barred surfperch (*Amphisticus argenteus*) in Southern California. Calif. Dept. Fish and Game, Fish Bull. 109: 1-79.

______________, C. Turner and E. Ebert. 1964. Artificial habitat in the marine environment. Calif. Dept. Fish and Game, Fish Bull. 124, 93 p.

Carlucci, A. F. 1970. Vitamin B12, thiamine and biotin. In J. D. H. Strickland (ed.), The ecology of the plankton off La Jolla, California, in the period April through September 1967. Bull. Scripps Inst. Oceanogr. 17: 23-31.

______________ and P. M. Bowes. 1970a. Production of vitamin B12, thiamine, and biotin by phytoplankton. J. Phycol. 6: 351-357.

______________________________. 1970b. Vitamin production and utilization by phytoplankton in mixed cultures. J. Phycol. 6: 393-400.

______________________________. 1972. Vitamin B12, thiamine, and biotin contents of marine phytoplankton. J. Phycol. 8: 133-137.

______________ and S. B. Silbernagel. 1969. Effect of vitamin concentrations on growth and development of vitamin-requiring algae. J. Phycol. 5: 64-67.

____________________________________ and P. M. McNally. 1969. Influence of temperature and solar radiation on persistence of vitamin B12, thiamine, and biotin in seawater. J. Phycol. 5: 302-312.

Carrick, R. and S. E. Ingham. 1962. Studies on the southern elephant seal *Mirounga leonina* (L.). II. Canine tooth structure in relation to function and age determination. C.S.I.R.O. Wildlife Research 7(2): 102-118.

Chapman, G. A. 1963. Mission Bay a review of previous studies and the status of the sportfishery. Calif. Dept. Fish and Game. 49(1): 30-43.

Chapman, V. J. 1961. A contribution to the ecology of *Egregia laevigata* Setchell I. Bot. mar., 3, 33-45.

____________. 1970. Seaweeds and their uses, 2nd edition, Methuen, London.

Charters, A. C. M. Neushul and C. Barilotti. 1969. The functional morphology of *Eisenia arborea*. Proc. Int. Seaweed Symp., 6, 89-105.

Clark, F. N. 1929. The life history of the California jacksmelt, *Atherinopsis californiensis* Calif. Div. Fish Game, Fish Bull. 16: 1-22.

Clark, T. A. 1970. Territorial behavior and population dynamics of a pomacentrid fish, the garibaldi, *Hypsypops rubicunda*. Ecol. Mongr. 40: 189-212.

Clarke, W. D. 1971. Mysids of the Southern Kelp region. In the biology of giant kelp beds (*Macrocystis*) in California. Nova Hedwigia, Suppl. 32, Cramer: 369-380.

Clendenning, K. A. 1958a. Red tide studies. Ann. Prog. Rept. Univ. Calif. Inst. Mar. Resources Ref. 58-11.

____________. 1958b. Physiology and biochemistry of giant kelp. Kelp Inv. Prog. Quart. Prog. Rept., 1 April-30 June 1958, Univ. Calif. Inst. Mar. Res., IMR Ref. 58-10, p. 25-35.

____________. 1959. Red tide in relation to organic pollution of coastal water. Ann. Progr. Rept. Univ. Calif. Inst. Mar. Resources Ref. 59-4.

____________. 1971. Organic productivity in kelp area. In: The biology of giant kelp beds (*Macrocystis*) in California, p. 259-264. Ed. by W. J. North. Nova Hedwigia, Suppl. 32, Cramer.

Cockerell, T. 1939. The marine invertebrate fauna of the California islands. Sixth Pac. Sci. Cong. Proc. 3: 501-504.

Coe, W. R. 1940. Revision of the nemertean fauna of the Pacific coasts of North, Central, and Northern South America. AhPE. 2(13): 247-323.

Collard, S. B. 1970. Forage of some Eastern Pacific midwater fishes. Copeida 1970(2): 348-354.

Colman, J. 1933. The nature of intertidal zonation of plants and animals. J. Mar. Biol. Assoc. U.K. 18: 435-76.

Connell, J. H. 1961. The influence of interspecific competition and other factors on the distribution of the barnacle Chthamalus stellatus, Ecology 42: 710-723.

Cooper, N. C. and G. R. Johnstone. 1944. The seasonal production of agar in *Gelidium cartilagineum*, a perennial red alga. Amer. J. Bot., 31, 638-640.

Copeland, B. J. and E. G. Fruh. 1970. Ecological studies of Galveston Bay 1969. Final report to Texas Water Quality Board, Galveston Bay study program. 482 p.

Corps of Engineers and Dames & Moore. 1971. National shoreline study, California regional inventory 103p. + appendix.

Craig, A. M. 1964. Histology of reproduction and the estrus cycle in the female fur seal *Callorhinus ursinus*. J. Fish Res. Bd. Canada, 21(4): 773-811.

Cubit, J. 1969. Behavior and physical factors causing migration and aggregation of the sand crab *Emerita analoga* (Stimpson).

Cupp, E. E. 1930. Quantitative studies of miscellaneous series of surface catches of marine diatoms and dinoflagellates taken between Seattle and the Canal Zone from 1924 to 1928. Trans. Amer. Microscop. Soc. 49: 238-245.

________. 1934. Analysis of marine plankton diatom collections taken from the Canal Zone to California during March, 1933. Trans. Amer. Microscop. Soc. 53: 22-29.

________. 1937. Seasonal distribution and occurrence of marine diatoms and dinoflagellates at Scotch Cap, Alaska. Bull. Scripps Inst. Oceanog., Tech. Ser. 4: 71-100.

________. 1943. Marine plankton diatoms of the west coast of North America. Bull. Scripps Inst. Oceanogr. 5: 1-128.

________ and W. E. Allen. 1938. Plankton diatoms of the Gulf of California obtained by Allan Hancock Pacific Expedition of 1937. Univ. South. Calif. Press, Allan Hancock Pacific Exped. 3: 61-99.

Cushing, D. H., 1962. Patchiness. J. Cons. Int. Explor. Mer. 153(26): 152-163.

Dailey, M. D. 1970. The transmission of *Parafilaroides decorus* (Nematoda: Metastrongyloidea) in the California sea lion (*Zalophus californianus*). Proc. Helminth. Soc. Wash. 37: 215-222.

__________. 1971. Distribution of helminths in the Dall Porpoise (*Phocoenoides dalli* True). J. Parasitol. 57: 1348.

Dailey, M. D. (unpublished). Lungworms of *Mirounga*.

____________ and R. L. Brownell. 1972. A checklist of marine mammal parasites. In Mammals of the sea. Biology and medicine. S. H. Ridgway, ed., Charles C. Thomas, Springfield, Ill. p. 528-589.

____________ and W. Perrin. 1973. Helminth parasites of porpoises of the genus *Stenella* in the eastern tropical Pacific, with descriptions of two new species: *Mastigonema stenellae* gen. et. sp. n. (Nematoda: Spiuroidea) and *Zalophotrema pacificum* sp. n. (Trematoda: Digenea). Fishery Bull. 71: 455-471.

____________ and W. A. Walker. (unpublished). Helminth infections in stranded cetaceans from Southern California.

Dales, R. P. 1953. The distribution of some heteropod molluscs off the Pacific Coast of North America. Proc. Zool. Soc. Lond. 122(4): 1007-1015.

__________. 1957. Pelagic polychaetes of the Pacific Ocean. Bull. Scripps Inst. Oceanogr. 7(2): 99-168.

Daugherty, Anita E. 1965. Marine mammals of California. State of California, The Resources Agency, Dept. of Fish and Game, Sacramento, Calif. 87 p.

Davies, D. H. 1968. Statistical analysis of the relation between kelp harvesting and sportfishing in the California kelp beds, p. 151-212. In: North, W. J., and C. L. Hubbs (eds), Utilization of kelp bed resources in Southern California. Calif. Dept. Fish Game Fish Bull. 139.

Davis, H. C., and H. Hidu. 1969. Effects of pesticides on embryonic development of clams and oysters and on survival and growth of the larvae. Fish. Bull. 67: 393-404.

Dawson, E. Y. 1941. A review of the genus *Rhodymenia* with descriptions of new species. Allan Hancock Pacific Exped., 3, 123-180.

__________. 1945. An annotated list of the marine algae and marine grasses of San Diego County, California. Occasional Papers, San Diego Society Nat. Hist., No. 7, 78 p.

__________. 1946. New and unreported marine algae from Southern California and northwestern Mexico. Bull. So. Calif. Acad. Scie., 44, 75-91.

__________. 1949. Contributions toward a marine flora of the Southern California Channel Islands. Allan Hancock Foundation Occasional Pap. No. 8, 57 p.

__________. 1950. Notes on Pacific Coast marine IV. Amer. J. Bot., 37, 149-58.

__________. 1952. Marine red algae of Pacific Mexico, Part 1. Bangiales to Corallinaceae subf. Corallinoideae. Allan Hancock Pacific Exped., 7, 1-239.

__________. 1954. Marine red algae of Pacific Mexico, Part 2. Cryptonemiales (Continued). Allan Hancock Pacific Exped., 17, 250-390.

__________. 1957. Notes on eastern Pacific insular marine algae. Los Angeles County Museum Contr. Sci., 8, 1-8.

__________. 1958. Notes on Pacific coast marine algae VII. Bull. So. Calif. Acad. Sci., 57, 65-80.

__________. 1959. A primary report on the benthic marine flora of Southern California. In: Oceanographic Survey of the continental shelf area of Southern California, p. 169-264. California State Water Pollution Control Board Publ., No. 20.

__________. 1960. Marine red algae of Pacific Mexico, Part 3. Cryptonemiales Corallinacea subf. Melobesioideae, Pacific Nat., 2, 1-125.

__________. 1961a. Marine red algae of Pacific Mexico, Part 4. Gigartinales. Pacific Nat., 2, 189-343.

__________. 1961b. A new sublittoral *Gracilariopsis* from Southern California, Bull. Res. Council Israel 10D, 34-36.

__________. 1962. Marine red algae of Pacific Mexico, Part 7. Ceramiaceae, Delesseriaceae. Allan Hancock Pacific Exped., 26, 1-108.

__________. 1963a. Marine red algae of Pacific Mexico, Part 6. Rhodymeniales. Nova Hedwigia, 5, 437-476.

__________. 1963b. Marine red algae of Pacific Mexico, Part 8. Ceramiales: Dasyaceae, Rhodomelaceae. Nova Hedwigia 6, 401-481.

__________. 1965. Chapter 8. Intertidal Algae. In: An oceanographic and biological survey of the Southern California mainland shelf, p. 220-231, 351-438. California State Water Quality Control Board Publ., 27.

__________. 1966. Seashore plants of Southern California, Univ. Calif. Press, 101 p.

____________ and M. Neushul. 1966. New records of marine algae from Anacapa Island, California. Nov. Hed., 12, 173-187.

______________________________ and W. D. Wildman. 1960. Seaweeds associated with kelp beds along Southern California and northwestern Mexico. Pacific Nat., 1, 1-81.

Dayton, Paul K. 1971. Competition, disturbance, and community organization: the provision and subsequent utilization of space in a rock intertidal community. Ecological Monographs, Vol. 41, No. 4, p. 351-388 p.

Delamure, S. L. 1955. The helminthofauna of marine mammale of the world in the light of their ecology and phylogeny. Moscow. 517 p. (in Russian).

DeLaubenfels, M. W. 1932. Marine and fresh water sponges of Calif. Proc. U. S. Nat. Mus., 81: 1-140.

DeLong, R. L. Wildlife biologist, National Marine Fisheries Service, Seattle, Wash.

____________, W. G. Gilmartin and J. G. Simpson. 1973. Premature births in California sea lions: Association with high organochlorine pollutant residue levels. Science 181: 1168-1169.

DeWitt, F. A., Jr. 1972. Bathymetric distributions of two common deep-sea fishes, *Cydothone acclinidens* and *C. signata* off Southern California. Copeia 1972(1): 88-96.

__________________and G. M. Cailliet. 1972. Feeding habits of two bristlemouth fishes, *Cyclothone acclinidens* and *C. signata*. Copeia 1972(4): 868-871.

Dillingham Corporation. 1971. An environmental evaluation of the Bolsa Chica area. Los Angeles, Signal Properties, Inc.

Dixon, P. S. 1973. Biology of the Rhodophyta. Edinburgh, Oliver and Boyd, 285 p.

Doty, Maxwell S. 1946. Critical tide factors that are correlated with the vertical distribution of marine algae and other organisms along the Pacific Coast. Ecology, 27: 315-328.

_______________. 1957. Rocky intertidal surfaces. Mem. Geol. Soc. Am. 67: 535-85.

Duke, T. W., J. I. Lowe and A. J. Wilson, Jr. 1970. A polychlorinated biphenyl (Arochlor 1254) in water, sediment, and biota of Escambia Bay, Florida. Bull. Environ. Contam. Toxicol. 5: 171-80.

Durham, J. W. and J. L. Bernard. 1952. Stony corals to the Eastern Pacific collected by the Velero III and the Velero IV. Allan Hancock Pacific Expeditions. 16(1): 1-104.

Ebeling, A. W., G. M. Cailliet, R. M. Ibara, F. A. DeWitt, Jr., and D. W. Brown, 1970. Ecological groups of deep-sea animals off Southern California. Bull. Los Angeles Co. Mus. Nat. Hist., Sci. No. 6: 1-43.

_____________, R. M. Ibara, R. J. Lavenberg, and F. J. Rohlf, 1970a. Ecological groups of deep-sea animals off Southern California. Bull. Los Angeles Co. Mus. Nat. Hist., Science No. 6: 1-43.

_____________, G. M. Cailliet, R. M. Ibara, F. A. DeWitt, Jr., and D. W. Brown, 1970b. Pelagic communities and sound scattering off Santa Barbara, California, p. 1-19. In: Farquhar, G. B. (ed.), Proc. Internat. Symp. Biol. Sound Scattering Ocean. Wash., D. C., Maury Center Ocean Sci., No. 5.

_____________, W. Werner, F. A. DeWitt, Sr., and G. M. Cailliet. 1971. Santa Barbara oil spill: short-term analysis of macroplankton and fish. EPA 15080 EALO 2/71, Univ. of Calif. Santa Barbara.

Ebert, E. E. and C. A. Turner, 1962. The nesting behavior, eggs, and larvae of the bluespot goby. Calif. Fish Game, 48(4): 249-252.

Efford, I. E. 1965. Aggregation in the sand crab, *Emerita analoga* (Stim-(Srimpson) (Decapoda, anomura). Crustaceana 10: 166-182.

Eisler, R. 1969. Acute toxicities of insecticides to marine decapod crustaceans. Crustaceana 16: 302-10.

Elton, C. 1946. Competition and the structure of ecological communities. J. Anim. Ecol. 15: 54-68.

Emerson, R. 1970. Some polychaetous annelids from the Santa Barbara shelf area. In: Biological and oceanographical survey of the Santa Barbara Channel oil spill, 1969-1970: 117-148.

Emery, K. O. 1960. The sea off Southern California. New York: John Wiley and Sons, Inc.

Endean, R., R. Kenny and W. Stephenson. 1956. The ecology and distribution of intertidal organisms on the rocky shores of the Queensland Mainland. Aust. J. Mar. F. Water Res. 7: 88-146.

Engler, R. H., M. J. Neat and R. E. Hillman. 1970. Sublethal chronic effects of DDT and Lindane on glyconlytic and glucconeogenic enzymes of the quahog, *Mercenaria mercenaria*. FAO Technical Conference on Marine Pollution and Its Effects on Living Resources and Fishing, 9-18 Dec. 1970, Rome, Italy. FIR:MP 70/E-13.

Eppley, R. W. 1970. Relationships of phytoplankton species distribution to the depth distribution of nitrate. In: J. D. H. Strickland (ed.), The ecology of the plankton off La Jolla, California, in the period April through September, 1967. Bull. Scripps Inst. Oceanogr. 17: 43-49.

_____________, A. F. Carlucci, O. Holm-Hansen, D. Kiefer, J. J. McCarthy, and P. M. Williams. 1972. Evidence for eutrophication in the sea near Southern California coastal sewage outfalls- July, 1970. Calif. Mar. Res. Comm., CALCOFI Rept. 16: 74-83.

_____________and J. L. Coatsworth. 1966. Culture of the marine phytoplankter *Dunialiella tertiolecta* with light-dark cycles. Arch. Mikrobiol. 55: 66-80.

_____________________________________, and L. Solorzano. 1969. Studies on nitrate reductase in marine phytoplankton. Limnol. Oceanogr. 14: 194-205.

_____________, J. N. Rogers and J. J. McCarthy. 1969. Half-saturation constants of uptake of nitrate and ammonium by marine phytoplankton. Limnol. Oceanogr. 14: 912-920.

_____________, F. M. H. Reid and J. D. H. Strickland. 1970. Estimates of phytoplankton crop size, growth rate, and primary production. In: J. D. H. Strickland (ed.), The ecology of the phytoplankton off La Jolla, California, in the period April through September 1967. Bull. Scripss Inst. Oceanogr. 17: 33-42.

_____________, O. Holm-Hansen and J. D. H. Strickland. 1968. Some observations on the vertical migration of dinoflagellates. J. Phycol. 4: 333-340.

_____________and P. R. Soan. 1966. Growth rates of marine phytoplankton: Correlation with light absorption by chlorophyll a. Physiol. Plant. 19: 912-920.

_____________, R. W. Holmes and E. Paasche. 1967. Periodicity in cell division and physiological behavior of *Ditylum brightwellii*, a marine planktonic diatom, during growth on light-dark cycles. Arch. Mikrobiol. 56: 305-323.

Esterly, C. O. 1905. The pelagic Copepoda of the San Diego region. Univ. Calif. Publ. Zool. 2(4): 113-233.

_____________. 1911. The vertical distribution of *Eucalanus elongatus* in the San Diego region during 1908. Univ. Calif. Publ. Zool. 8(1): 1-7.

_____________. 1912. The occurrence and vertical distribution of the Copepoda of the San Diego region with particular reference to nineteen species. Univ. Calif. Publ. Zool. 9: 253-340.

_____________. 1914a. A study of occurrence and manner of distribution of the Ctenophora of the San Diego region. Univ. Calif. Publ. Zool. 13(2): 21-38.

______________. 1914b. The vertical distribution and movements of the Schizopoda of the San Diego region. Univ. Calif. Publ. Zool. 13(5): 123-145.

______________. 1917. Occurrence of a rhythm in the geotropism of two species of plankton copepods when certain recurring conditions are absent. Univ. Calif. Publ. Zool. 16: 393-400.

______________. 1923. Preliminary statistical report on the occurrence of marine Copepoda in plankton off La Jolla. Univ. Calif. Publ. Zool. 22(10): 417-433.

______________. 1928. The periodic occurrence of Copepoda in the marine plankton of two successive years at La Jolla, California. Bull. Scripps Inst. Oceanogr., Univ. Calif., tech. ser. 1: 247-345.

Evans, W. E. 1971. Orientation behavior of delphinids: Radio telemetric studies. Ann. N. Y. Acad. Sc. 188: 142-160.

Fager, E. W. 1957. Determination and analysis of recurrent groups. Ecology, 38: 586-595.

____________. 1972. Diversity: a sampling study. American Nat. 106 (949): 293-310.

____________ and J. A. McGowan. 1963. Zooplankton species groups in the North Pacific. Science, 140: 453-460.

Fauchald, K. 1970. The benthic fauna in the Santa Barbara Channel following the January, 1969, oil spill. In Biological and oceanographic survey of Santa Barbara Channel oil spill; 1969-1970, Vol. 1: 61-116.

Fay, R. C.. 1972. Southern California's deteriorating marine environment. Cntr. Calif. Pub. Affairs, Claremont: 76 p.

__________ and J. V. Johnson. 1971. Observations on the distribution and ecology of the litteral Ascidian of the mainland coast of Southern California. Bull. So. Calif. Acad. Sci. 70(3): 114-124.

Felts, R. W. 1973. Seasonal distribution and abundance of the chaetognaths from Anaheim Bay, California and the adjacent waters. M. S. thesis, Calif. State Univ., Long Beach. 118 p.

Filice, F. P. 1954a. An ecological survey of the Castro Creek area in San Pablo Bay. Wasmann J. Biol. 12: 1-24.

Fish, P. A. 1899. The brain of the fur seal, *Callorhinus ursinus*; with a comparative description of those of *Zalophus californianus*, *Phoca vitulina*, *Ursus americanus* and *Manachus tropicalis*. In Jordan, D. S. 1899, The fur seals and fur-seal islands of the North Pacific Ocean. Part 3. Washington.

__________. 1903. The cerebral fissures of the Atlantic walrus. Proc. U. S. Nat. Mus. 26: 675-688.

Fisher, W. K. 1952. The Sipunculid worms of calif. and Baja, Calif. No. 3306. Proc. of U. S. Nat. Mus. 2: 371-450.

Fitch, J. E. 1953. Common marine bivalves of California. Calif. Dept. Fish & Game, Fish. Bull., No. 90, 102 p., 1 pl., 63 figs.

___________. 1963. A review of the fishes of the genus *Pleuronichthys*. L. A. Co. Mus. Natur. His. Contrib. Sci. 76: 1-33.

___________. 1967. The marine fish fauna, based primarily on otoliths, of a lower Pleistocene deposit at San Pedro, California (LACMIP 332, San Pedro Sand). L. A. Co. Mus. Natur. His. Contrib. Sci. 128: 1-23.

___________. 1968. Otoliths and other fish remains from the Timms Point silt (Early Pleistocene) at San Pedro, California. L. A. Co. Mus. Natur. His. Contrib. Sci. 146: 1-29.

___________and R. J. Lavenburg. 1971. Marine food and game fishes of California. Univ. Calif. Press, Berkeley. 179 p.

Fleminger, A. 1964. Distributional atlas of calanoid copepods in the California Current region. CalCOFI Atlas No. 2: 1-313.

____________. 1967. Distributional atlas of calanoid copepods in the California Current region, Part II. CalCOFI Atlas No. 7: vii-xvi, 1-213.

Forster, G. R. 1959. The ecology of *Echinus esculentis* L. Quantitative distribution and rate of feeding. Jour. Mar. Biol. Assoc., 38: 361-367.

Foster, M. 1971. The algal turf community in the nest of the ocean goldfish, *Hypsypops rubicunda*. Proc. Int. Seaweed Symp., 7, 55-60.

__________, M. Neushul, and R. Zingmark. 1970. The Santa Barbara oil spill II. Initial effects on littoral and kelp bed organisms. Water Pollution Control Res. Ser. 15080 DZR, U. S. Dept. Interior, 25-44.

Fraser, F. C. and P. E. Purves. 1960. Hearing in cetaceans. Bull. Brit. Mus. (Nat. Hist.). Zoology 7(1): 1-140.

Frey, H. W. (ed.). 1971. California's living marine resources and their utilization. Calif. Dept. Fish and Game, 148 p.

__________, R. F. Hein, and J. L. Spruill. 1970. The natural resources of upper Newport Bay and recommendation concerning the Bay's development. Resources Agency, Dept. Fish and Game.

Fry, D. H. 1939. A winter influx of sea lions from Lower California. Calif. Dept. Fish and Game 25: 245-250.

Gardner, N. L. 1913. New Fucaceae. Univ. Calif. Publ. Bot., 4, 36-54.

____________. 1917. New Pacific Coast marine algae. I. Univ. Calif. Publ. Bot., 6, 377-416.

____________. 1926. New Rhodophyceae from the Pacific Coast of North America I. Univ. Calif. Publ. Bot., 13, 205-226.

____________. 1927a. New species of *Gelidium* on the Pacific Coast of North America. Univ. Calif. Publ. Bot., 13, 273-318.

____________. 1927b. New Rhodophyceae from the Pacific Coast of North America II. Univ. Calif. Publ. Bot., 13, 235-272.

____________. 1927c. New Rhodophyceae from the Pacific Coast of North America III. Univ. Calif. Publ., Bot., 13, 333-368.

____________. 1927d. New Rhodophyceae from the Pacific Coast of North America IV. Univ. Calif. Publ. Bot., 13, 373-402.

____________. 1927e. New Rhodophyceae from the Pacific Coast of North America V. Univ. Calif. Publ. Bot., 13, 404-415.

____________. 1927f. New Rhodophyceae from the Pacific Coast of North America VI. Univ. Calif. Publ. Bot., 14, 99-138.

____________. 1940. New species of Melanophyceae from the Pacific Coast of North America. Univ. Calif. Publ. Bot., 19, 267-286.

Garth, J. S. 1958. Bruchyura of the Pacific Coast of America, Oxyrhyncha. AHPE. 21: 1-499.

Gentry, R. L. 1970. Social behavior of the Steller sea lion. Dissertation, Santa Cruz, Calif., Department of Biological Sciences, University of California, 113 p.

Ghelandi, R. J. 1971. "Species" structure of the animal community that lives in *Macrocystis pyrifers* holdfasts. In the biology of giant kelp beds (*Macrocystis*) in California. Nova Hedwigia, Suppl. 32, Cramer: 381-420.

Gilmore, R. M. 1956. The California gray whale. Zoonooz (San Diego). February.

____________. 1958. The story of the gray whale. Privately printed. San Diego, Calif., 116 p., 9 illus.

Given, R. R. The Cumacean fauna of the So. Calif. continental shelf, No. 1: family Leuconidae. Bull. So. Calif. Acad. of Sci. 60(3): 130-146.

__________. 1964. The Cumacean fauna of the So. Calif. continental shelf, No. 2: the new family *Mesolampridae*. *Crustaceana*. 7(4): 284-292.

__________ and G. F. Jones. 1962. A study of the Meiofauna of the mainland shelf of Southern California. In Proceedings of the First National Coastal and Shallow Water Research Conference, 1961, Tallahasse, Fla., Natl. Sci. Found., ONR., p. 652-653.

__________ and D. Lees. Santa Catalina Island biological survey, Rept. 1. Allan Hancock Foundation: 126 p.

Grau, Gilbert. 1959. Pectinidae of the Eastern Pacific, Allan Hancock Pacific Expeditions, 23: 1-158.

Gress, F. 1970. Reproductive status of the California brown pelican in 1970, with notes on breeding biology and natural history. Calif. Dept. Fish and Game, Wildlife Management Branch Administrative Rept. No. 70-6: 21 p.

Gwen, R. R. 1974. U.S.C. Avalon Marine Biol. Lab., March telephone communication.

Hagerman, F. B. 1952. A biology of the dover sole. Calif. Dept. Fish and Game, Fish Bull. 85: 1-48.

Haig, J. 1960. The Porcellanidae (Crustacea Anomura) of the Eastern Pacific. AHPE. Vol. 24.

Hall, John. Santa Cruz, Dept. Biology, Univ. of Calif.

Hand, C. H., and L. Bemu, Jr. 1959. Food of the Pacific sardine (*Sardiaops caerulea*). U. S. Fish Wildl. Ser., Fish Bull. 164: 175-184.

Harrison, R. J. 1960. Reproduction and reproductive organs in common seals (*Phoca vitulina*) in the Wash, East Anglia. Mammalia, Paris 24: 372-385.

__________. 1969. Reproduction and reproductive organs. In: Anderson, H. T. (ed.), The biology of marine mammals.

__________, R. L. Brownell, and R. C. Boice. 1972. Reproduction and gonadal appearances in some Odontocetis. Functional anatomy of marine mammals, Vol. 1 (Harrison, R. J., ed.), New York, Academic Press, p. 361-429.

_______________, L. H. Matthews, and J. M. Roberts. 1952. Reproduction in some Pinnipedia. London, Trans. Zool. Soc., 27(5): 437-540.

_______________ and J. D. W. Tomlinson. 1956. Observations on the venous system in certain Pinnipedia and Cetacea. London, Proc. Zool. Soc. 126: 205-233.

______________________________________. 1960. Normal and experimental diving in the Common Seal (*Phoca vitulina*). Paris, Mammalia, 24: 386-399.

_______________, I. W. Rowlands, H. W. Whitling, and B. A. Young. 1962. Growth and structure of the thyroid gland in the Common Seal (*Phoca vitulina*). J. Anat. 93: 3-14.

Hart, J. F. L. 1964. Shrimps of the genus *Betaeus* on the Pacific coast of North America with descriptions of three new species. Proc. U. S. Nat. Mus. 115(3490): 431-466.

Hart, J. S. and L. Irving. 1959. The energetics of Harbor Seals in air and in water with special consideration of seasonal changes. Can. J. Zool. 37: 447-457.

Hartman, Olga. 1955a. Quantitative survey of the benthos of San Pedro Basin, Southern California. Allan Hancock Pac. Exped. 19: 1-185, 2 charts, 7 pls.

____________. 1955b. Endemism in the north Pacific Ocean, with emphasis on the distribution of marine annelids, and descriptions of new or little known species. In Essays in the natural sciences in honor of Captain Allan Hancock. Los Angeles, p. 39-60, 4 pls.

____________. 1963. Submarine canyons of Southern California, Part 2: Biology. Allan Hancock Pacific Expeditions, 27(2): 1-424.

____________. 1966. Quantitative survey of the benthos of San Pedro Basin, Southern California Part II final results and conclusions. Allan Hancock Pacific Expeditions, 19(2): 456 p.

____________. 1968. Atlas of the Errantiate Polychaetous Annelids from California. Allan Hancock Foundation. Univ. of So. Calif. Press.

____________. 1969. Atlas of the Sedentariate Polychaetous Annelids from Calif. Allan Hancock Foundation. Univ. of So. Calif. Press.

____________, and L. J. Barnard. 1958. The benthic fauna of the deep basins off Southern California, Part 1. Allan Hancock Pacific Expeditons, 22(1): 1-67.

_____________________________. 1960. The benthic fauna of the deep basins off Southern California, Part 2. Allan Hancock Pacific Expeditions, 22(2): 68-297.

Hedgpeth, J. W. 1957a. Concepts of marine ecology. Chapt. 3 In Treatise on marine Ecology and paleoecology, Geol. Soc. Amer. Me. 67, Vol. 1: 29-52, 7 figs.

_____________. 1957b. Sandy beaches. In Treatise on marine ecology and paleoecology. Geol. Soc. Am. Mem. 67(1): 587-608.

_____________and Hinton. 1961. Common seashore life of Southern California. Healdsburg, Calif., Naturegraph Co., 64 p.

Herschkovitz, Philip. 1961. On the nomenclature of certain whales. Fieldiana Zool. 39(49): 547-565.

Hewatt, W. G. 1946. Marine ecological studies on Santa Cruz Island, California. Ecol. Monogr. 16: 185-210.

Hilton, W. A. 1942. Pynogonids from Hancock Expeditions. Allan Hancock Pacific Exped. 5(9): 277-340.

Hoagland, D. R. 1915. Organic constituents of Pacific Coast kelps. Jour. Agric. Res., 4, 39-58.

_____________and L. L. Leib. 1915. The complex carbohydrates and forms of sulfur in marine algae of the Pacific Coast. Jour. Biol. Chem., 23, 287-297.

Hollenberg, G. J. 1943. New marine algae from Southern California. II. Amer. J. Bot., 30, 571-579.

______________. 1944. An account of the species of *Polysiphonia* on the Pacific Coast of North America II. *Polysiphonia*. Amer. J. Bot., 31, 474-483.

______________. 1945. New marine algae from Southern California III. Amer. J. Bot., 32, 447-451.

______________. 1948. Notes on Pacific Coast marine algae. Madrono, 8, 155-162.

______________. 1958. Phycological notes II. Bull., Torrey Bot., Club., 85, 63-69.

______________. 1970. Phycological notes IV., including new marine algae and new records for California. Phycologia, 9, 61-72.

______________. 1971. Phycological notes V. New species of marine algae from California. Phycologia 10, 11-16.

________________ and I. A. Abbott. 1966. Supplement to Smith's marine algae of the Monterey Peninsula. Stanford University Press.

Holmes, R. W. 1966. Short-term temperature and light conditons associated with auxospore formation in the marine centric diatom *Coscinodiscus cocinnus* W. Smith, Nature 209: 217-218.

__________. 1967. Auxospore formation in two marine clones of the diatom genus *Coscinodiscus*. Amer. J. Bot. 54: 163-168.

__________ and B. E. F. Reimann. 1966. Variation in valve morphology during the life cycle of the marine diatom *Coscinodiscus cocinnus* Phycologia 5: 234-244.

__________, P. M. Williams and R. W. Eppley. 1967. Red water in La Jolla Bay, 1964-1966. Limnol. Oceanogr. 12: 503-512.

Holthuis, L. 1951. A general revision of the Palaemonidae (Crustacea, Decapoda, Natantia) of the Americas. I. A. H. F. Occ. Papers, 11: 1-332.

__________. 1952. A general revision of the Palaemoninae (Crustacea, Decapods Natantia) of Americas. II. The subfamily Palaemoninae. A. H. F. P. Occ. Papers. No. 12: 1-396.

Horn, M. H. 1974. Fishes of Southern California, a literature survey. Southern Calif. Ocean Studues Consortium, 63 p. + figures.

Howell, A. B. Razier. 1928. Contributions to the comparative anatomy of the eared and earless seals (genera *Zalophus* and *Phoca*). Proc. U. S. Nat. Mus. 73: Art. 15. 1-142.

Howey, T. W. 1971. The occurrence and abundance of copepods in Anaheim Bay and the adjacent waters. M. S. thesis, Calif. State Univ., Long Beach. 87 p.

Hubbs, C. L. 1956. Back from oblivion; Guadalupe fur seal. Still a living species. Pacific Discovery 9: 14-21.

__________. 1960. The marine vertebrates of the outer coast. Syst. Zool. 9(3,4): 134-147.

Hubbs, K. 1948. Changes in the fish fauna of western North America correlated with changes in ocean temperature. J. Mar. Res. 7(3): 459-482.

Hulings, N. and J. Gray. 1971. A manual for the study of Meiofauna. Smith. Cont. in Zoo. 78: 84 p.

Humm, H. J. 1951. The red algae of economic importance. Marine products of commerce, 2nd edition. Ed. by Tressler, D. K. and Lemon, J. M., New York, Reinhold, p. 47-93.

Hunt, G. L., Jr. and M. V. Hunt. 1974. Trophic levels and turnover rates. The avifauna of Santa Barbara Island. condor (impress).

Hunter, J. R. 1972. Swimming and feeding behavior of larval anchovy *Engraulis mordax*. Fish. Bull. 70(3): 821-383.

Hyman, L. H. 1953. The polyclad flatworms of the Pacific coast of North America, Bull. Amer. Mus. Nat. Hist. 100(2): 392.

Ingles, L. G. 1965. Mammals of the Pacific States. Stanford Univ. Press, 506 p.

Irving, L. 1969. Temperature regulation in marine mammals. H. T. Andersen (ed.), The biology of marine mammals. New York, Academic Press, p. 147-174.

Iversen, E. S. 1968. Farming the edge of the sea. London, Fishing News (Books) Ltd., 301 p.

Jehl, J. R. 1973. Studies of declining population of brown pelicans in N. W. Baja, California. Condor 75: 69-79.

Jitts, H. R., C. D. McAllister, K. Stephens and J. D. H. Strickland. 1964. The cell division rates of some marine phytoplankters as a function of light and temperature. J. Fish. Res. Bd. Can. 21: 139-157.

Johnson, M. E. and H. J. Snook. 1955. Seashore animals of the Pacific Coast, New York, Dover Publ. Inc., p. 659.

Johnson, N. K. 1972. Origin and differentiation of the avifauna of the Channel Islands, California. Condor 74: 295-315.

Johnson, P. T. 1971a. Studies on unhealthy-appearing urchins from Whites Point. In North, W. J., 1970-71, Annual report. Kelp habitat improvement Project. W. M. Keck Laboratory, Calif. Inst. Techn.

_____________. 1971b. Studies from deseased urchins from Point Loma. In North, W. J., 1970-71, Annual report, Kelp Habitat Improvement Project. W. M. Keck Laboratory, Calif. Inst. Techn.

Jones, G. F. 1964. Redescription of *Bolbella californica* (Enchelidiidae: Nematoda), with notes on its ecology off Southern California Pac. Sci., 18(2): 160-165.

___________. 1967. The benthic macrofauna off the mainland shelf of Southern California. Ph. D. thesis, Los Angeles, Univ. So. Calif.

___________. 1969. The benthic macrofauna of the mainland shelf of Southern California. Allan Hancock Foundation Monogr. Mar. Biol. 4: 1-219.

___________and J. L. Bernard. 1963. The distribution and abundance of the inarticulate Brachiopod *Glottidia albida* (Hinds) on the mainland shelf of Southern Calif. Pac. Nat., 4(2): 28-52.

Jones, L. G. 1971. Studies on selected small herbivorous invertebrates inhabiting *macrocystis* canopies and holdfasts in Southern California kelp beds. In The biology of giant kelp beds (*Macrocystis*) in California. Nova Hedwigia, Suppl. 32, Cramer: 343-367.

Jones, N. S. 1950. Marine bottom communities. Biol. Rev. 25: 283-313.

Jow, T. 1969. Cruise report 69-S-5, bottom fish program. Menlo Park, Calif. Dept. Fish and Game, (Mimeo).

Juday, C. 1906. Ostracoda of the San Diego region. I. Halocypridae. Univ. Calif. Publ. Zool. 3(2): 13-38.

Kelco. 1961. Algin. Kelco Co., 1010 2nd Ave., San Diego, Calif., 12 p.

Kenyon, K. W. and F. Wilke. 1953. Migration of the Northern fur seal, *Callorhinus ursinus*. J. Mamm. 34: 86-98.

__________ and Victor B. Scheffer. 1953. The seals, sea lions and sea otters of the Pacific Coast. Wildlife Leaflet No. 344, U. S. Fish and Wildlife Service, 28 p.

______________________________. 1954. A population study of the Alaska fur seal herd. U. S. Dept. Int. Special Scientific Report. Wildlife No. 12.

Keys, A. B. 1930. A study of the selective action of deceased salinity and asphyxiation on the Pacific killifish, *Fundulus pairipinnis*. Bull. Scripps Inst. Oceanogr. (New Ser.) 2: 417-490.

King, Judith E. 1964. Seals of the world. London, British Museum of Natural History, 154 p.

Klingbeil, R. A. 1972. A comparative study of the food and feeding of the telcostean fishes in Anaheim Bay, California. M. A. Thesis, Calif. State Univ., Long Beach, 129 p.

Klopfer, P. H. and B. K. Gilbert. 1966. A note on retrieval and recognition of young in the elephant seal, *Mirounga angustrirostris*. Z. Tierpsychol. 6: 757-760.

Kofoid, C. A. 1906a. Dinoflagellata of the San Diego region I. On *Heterodinium*, a new genus of the Peridinidae. Univ. Calif. Publ. Zool. 2: 341-368.

__________. 1906b. Dinoflagellata of the San Diego Region II. On *Triposolenia*, a new genus of the Dinophysidae. Univ. Calif. Publ. Zool. 3: 93-116.

____________. 1907. Dinoflagellata of the San Diego region III. Descriptions of new species. Univ. Calif. Publ. Zool. 3: 299-340.

____________. 1911a. Dinoflagellata of the San Diego region IV. The genus *Gonyaulax* with notes on its skeletal morphology and a discussion of its generic and specific characters. Univ. Calif. Publ. Zool. 8: 187-286.

____________. 1911b. Dinoflagellata of the San Diego region V. On *Spiraulax* a new genus of the Peridinidae. Univ. Calif. Publ. Zool. 8: 295-300.

_____________and O. Swezy. 1921. The free-living unarmored dinoflagellata. Mem. Univ. Calif. 5: 1-562.

Kramer, D. 1960. Development of eggs and larvae of Pacific mackerel and distribution and abundance of larvae 1952-56. U. S. Fish. Wildl. Ser., Fish. Bull. 50: 393-438.

Kylin, H. 1941. Califonishche Rhodophyceen. Lunds Univ. Arsskr., N. F., 37, 1-52.

Lackey, J. B. 1938. The manipulation and counting of river plankton and changes in some organisms due to formalin preservation. Public Health Rept. 53: 2050-2093.

_____________and K. A. Clendenning. 1963. A possible fish-killing yellow tide in California waters. J. Fla. Acad. Sci. 26: 263-268.

Lane, E. D. and C. W. Hill (eds.). 1974. Marine resources of Anaheim Bay. Calif. Dept. Fish and Game Fish Bull. (In press).

Lasker, R., H. M. Feder, G. H. Theilacker, and R. C. May. 1970. Feeding growth, and survival of *Engraulis mordax* larvae reared in the laboratory. Mar. Biol. 5: 353- .

Lavenberg, R. J. and A. W. Ebeling. 1967. Distribution of midwater fishes among deep water basins of the Southern California shelf, p. 185-201. In: Philbrick, R. N. (ed.), Proc. Symp. Biol. Calif. Is. Santa Barbara Botanic Garden, Inc.

Leatherwood, J. S., R. F. Green and W. A. Walker. 1974. Observations of the Northern Right Whale Dolphin *Lissodelphis borealis* in California and Alaskan waters. Paper to be presented May 4, 1974, So. Calif. Acad. Sci., CSU, Fullerton.

________________, G. E. Lingle, J. D. Hall and W. E. Evans. (unpublished). Cetaceans of the Southern California continental borderland: Results of aerial and shipboard surveys 1968-1974.

LeBoeuf, B. J. 1971. The aggression of breeding bulls. Nat. Hist. 80(2): 82-94.

______________. 1972. Sexual behavior of the northern elephant seal, *Mirounga angustirostris* ehaviour 41: 1-26.

______________and R. S. Peterson. 1968. Behavior of the northern elephant seal. Ano Nuevo Reports 2: 6-20. Univ. of Calif., Santa Cruz.

______________________________. 1969. Social status and mating activity in elephant seals. Science 163: 91-93.

______________and M. L. Bonnell. 1971. DDT in California sea lions. Nature 234: 108-110.

Lees, D. C. 1968. The addition of the hydroid *Cladocoryne floccosa* to the Calif. marine fauna. Bull. So. Cal. Acad. Sci. 67(1): 59-64.

Leighton, D. L. 1966. Studies of food preference in algivorous invertebrates of Southern California kelp beds. Pac. Sci., Vol. 20, No. 1, p. 104-113.

______________. 1971. Grazing activities of benthic invertebrates in Southern California kelp beds. In the biology of giant kelp beds (*Macrocystis*) in California. Nova Hedwigia, Suppl. 32, Cramer: 421-453.

_______________, L. G. Jones and W. J. North. 1967. Ecological relationships between giant kelp and sea urchins in Southern California. Proc. Int. Seaweed Sym., 5: 141-153.

Leong, R. 1971. Induced spawning of the northern anchovy, *Engraulis mordax* Girard. Fish. Bull. 69(2): 357-360.

_________and C. P. O'Connell. 1969. A laboratory study of particulate and filter feeding of the northern anchovy (*Engraulis mordax*). J. Fish. Res. Bd. Canada 26: 557-582.

Lillelund, K., and R. Lasker. 1971. Laboratory studies of predation by marine copepods on fish larvae. Fish. Bull. 69(3): 655-667.

Limbaugh, C. 1955. Fish life in the kelp beds and the effects of kelp harvesting. Univ. Calif. Inst. Mar. Res., IMR Ref. 55-9, 158 p.

Littler, M. M. and S. N. Murray. 1974. Primary productivity of dominant intertidal macrophytes. p. 84-102, In: Biological features of intertidal communities near the U. S. Navy sewage outfall, Wilson Cove, San Clemente Island, California. Ed. by: Murray, S. N. and Littler, M. M. USN Tech. Pap. (In press).

Loukashkin, A. S. 1970. On the diet and feeding behavior of the northern anchovy, *Engraulis mordax* Girard. Proc. Calif. Acad. Sci. Ser. 4, 37: 419-458.

Lyon, G. M. 1937. Pinnipeds and a sea otter from the Point Mugu shell mound of California. Univ. Calif. Pub. Biol. Sci. 1: 133-168.

MacFarland, F. M. 1966. Studies of Opistobranchiate Mollusks of the Pacific Coast of North America, Calif. Acad. Sci. Memoirs, VI: 1-559.

MacGregor, J. S. 1966. Synopsis on the biology of the jack mackerel (*Trachurus symmetricus*). U. S. Fish. Wildl. Ser., Spec. Sci. Rept. Fish., 526: 1-16.

______________. 1968. Fecundity of the northern anchovy, *Engraulis mordax* Girard. Calif. Fish and Game 54(4): 281-288.

McCarthy, J. J. 1971. The role of urea in marine phytoplankton ecology. Ph. D. Thesis. Scripps Institution of Oceanography, La Jolla, California. 165 p.

______________. 1972a. The uptake of urea by marine phytoplankton. J. Phycol. 8: 216-222.

______________. 1972b. The uptake of urea by natural populations of marine phytoplankton. Limnol. Oceanogr. 17: 738-748.

______________ and R. W. Eppley. 1972. A comparison of chemical isotopic, and enzymatic methods of measuring nitrogen assimilation of marine phytoplankton. Limnol. Oceanogr. 17: 371-382.

McGary, J. W., J. J. Graham, and T. Otsu. 1961. Oceanography and North Pacific albacore. Calif. Marine Research Comm., Cooperative Oceanic Fisheries Investigations. 8: 45-53.

McGinnis, D. R. 1971. Observations on the zooplankton of the eastern Santa Barbara Channel from May, 1969 to March, 1970, p. 49-59. In: Biological and oceanographic survey of the Santa Barbara Channel oil spill 1969-1970. Vol. I, Biology and Bacteriology. Comp. by D. Straughan.

McGowan, J. A. 1967. Distributional atlas of pelagic molluscs in the California Current region. CalCOFI Atlas No. 6: 1-218.

McIlhattan, T. J., J. W. Martin, R. J. Wagner and J. O. Iverson. 1971. Isolation of *Leptospira pomona* from a naturally infected California sea lion, Sonoma County, California. J. Wildl. Dis. 7: 195-197.

McKee, A. 1967. Farming the sea. London, Souvenier Press, 314 p.

McPeak, R. H. 1968. A new species of Acontiate anemone from So. Calif. (Sagartiidae: sagartia). Bull. So. Cal. Acad. Sci. 67(3): 182-195.

Margalef, R. 1958. Information theory in ecology. Gen. Syst. 3: 36-71.

__________. 1968. Perspectives in ecological theory. Chicago, Univ. Chicago Press.

Margolis, L. and M. Dailey. 1972. Revised annotated list of parasites from sea mammals caught off the West Coast of North America. NOAA Technical Reports NMFS SSRF-647, p. 23.

Marine Advisors, Inc. 1963. Oceanographic investigation for proposed Cardiff-Solana Beach sewage outfall. Prepared for Special District Services, County of San Diego, 23 p.

Marr, J. C. 1960. The causes of the major variations in the catch of the Pacific sardine. In: Proceedings of the World Scientific Meeting, the biology of sardines and related species. Food and Agriculture Organization of the U. N., Rome 3: 667-791.

Mate, B. R. 1973. Population kinetics and related ecology of the Northern Sea Lion, *Eumetopias jubatus*, and the California Sea Lion, *Zalophus californianus*, along the Oregon Coast. Dissertation. Dept. Biology, University of Oregon, Eugene, 93 p.

Mattox, N. T. 1955. Observations on the Brachiopod communities near Santa Catalina Island. Essays in the Nat. Sci. in honor of Captain Allan Hancock. Hancock Found. USC Press.

Mearns, A. J. and M. J. Allen. 1973. Checklist of inshore demersal fishes from Southern and central California. SCCWRP Tech. Rept. TM206: 1-10.

Menzies, R. J. 1953. The apseudid Chelifera of the eastern tropical and north temperate Pacific Ocean. Bull. Mus. Comp. Zool. 107(9): 443-496.

Messersmith, J. D. 1969. The northern anchovy (*Engraulis mordax*) and its fishery 1965-1968. Calif. Dept. Fish and Game, Fish Bull. 147: 102 p.

Michael, E. 1911. Classification and vertical distribution of the Chaetognatha of the San Diego region. Univ. Calif. Publ. Zool. 8(3): 21-186.

__________. 1913. *Sagitta californica*, n. sp., from the San Diego region. Univ. Calif. Publ. Zool. 11(5): 89-126.

Miller, D. J. and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish and Game Fish Bull. 157: 1-235.

Miller, Gerrit S. and R. Kellogg. 1955. List of the North American Recent mammals. U. S. Nat. Mus. Publ. No. 205, 954 p.

Mitchell, E. 1965. Evidence for mass stranding of the False Killer Whale (*Pseudorca crassidens*) in the Eastern North Pacific Ocean. Norsk Hvalfangst-Tidende 8: 172-177.

Moberg, E. G. 1928. The interrelationship between diatoms, their chemical environment and upwelling water in the sea, off the coast of Southern California. Proc. U. S. Nat. Acad. Sci. 14: 511-517.

Moitoza, J. R. 1971. The effect of DDT on spine regeneration in sea urchins as measured by the uptake of calcium-45. Unpublished MS for Biology 175-M, on file at Hopkins Marine Station Library, Pacific Grove, Calif.

Montagna, W. and R. J. Harrison. 1957. Specialisations in the skin of the seal (*Phoca vitulina*). Am. J. Anat. 100: 81-114.

Moore, Joseph Curtis and E. Clark. 1963. Discovery of right whales in the Gulf of Mexico. Science, 141: 269.

Moser, H. G. 1966. Reproductive and developmental biology of the rockfishes (*Sebastodes* spp.) off California. Ph. D. diss. Univ. S. California, L. A., Calif.

__________. 1967. Reproduction and development of *Sebastodes paucispinis* and comparison with other rockfishes off Southern California. Copeia 1967(4): 773-797.

__________ and E. A. Ahlstrom. 1970. Development of lanternfishes (family *Myctophidae*) in the California Current. Part I. Species with narrow-eyed larvae. Bull. L. A. Co. Mus. Natur. Hist. Sci. 7: 1-145.

Mullin, M. M. and E. R. Brooks. 1970. Production of the planktonic copepod, *Calanus helgolandicus*. Part VII, p. 89-103. The ecology of the plankton off La Jolla, California, in the period April through September, 1967. Bull. Scripps Inst. Oceanogr., Vol. 17.

____________________. 1972. The vertical distribution of juvenile *Calanus* ,Copepoda) and phytoplankton within the upper 50m of water off La Jolla, California, p. 347-354. In: Biological oceanography of the Northern North Pacific Ocean. A. Y. Takenouti (chief ed.), Idemitsu Shoten, Tokyo.

Murphy, G. I. 1966. Population biology of the Pacific sardine (*Sardinops caerulea*). Proc. Calif. Acad. Sci. 4th Ser. 34(1): 1-84.

Murray, S. N. and M. M. Littler. 1974a. Biological features of intertidal communities near the U. S. Navy sewage outfall, Wilson Cove, San Clemente Island, California. USN Tch. Pap. (In press).

____________________. 1974b. Analyses of standing stock and community structure of intertidal macro-organisms. In: Murray, S. N. and Littler, M. M. (Eds.) Biological features of intertidal communities near the U. S. Navy sewage outfall Wilson Cove, San Clemente Island, California. USN Tch Pap. (In press).

____________. 1974c. Benthic algae and grasses. In: A summary of knowledge of the Southern California coastal zone and offshore areas. The Southern California Ocean Studies Consortium.

National Academy of Science. 1971. Chlorinated hydrocarbons in marine environment. Committee on Oceanography, Panel on Monitoring Persistent Pesticides in the Marine Environment.

Neushul, M., W. D. Clarke, and D. W. Brown. 1967. Subtidal plant and animal communities of the Southern California Islands. In: Proceedings Symposium Biology California Islands, p. 37-55. Ed. by R. N. Philbrick. Santa Barbara Botanic Garden, Inc., California.

Nicholson, N. L. and R. L. Cimberg. 1971. The Santa Barbara oil spills of 1969: A post-spill survey of the rocky intertidal. In: Biological and oceanographical survey of the Santa Barbara Channel oil spill 1969-1970, Vol. 1, p. 325-399. Ed. by D. Straughan. Allan Hancock Foundation, Univ. of So. Calif.

Nishiwaki, M. 1972. General biology. In: Mammals of the sea. Biology and Medicine. S. H. Ridgway, ed., Charles C. Thomas, Springfield, Ill, p. 3-204.

Norris, K. S. and J. H. Prescott. 1961. Observations on Pacific cetaceans of California and Mexican waters. Univ. Calif. Publ. Zool. 63: 291-402.

North, W. J. 1958. Experimental ecology. Kelp Inv. Prog., Quart. Prog. Rpt., 1 Oct.-31 Dec., 1957, Univ. Calif., Inst. Mar. Res., IMR Ref. 58-3, p. 8-18.

____________. 1961. Experimental ecology. Kelp Inv. Prog., Final Rpt., Univ. Calif., Inst. Mar. Res., Unpublished, 23 p.

____________. 1964. Experimental transplantation of the giant kelp, *Macrocystis pyrifera*. Proc. 4th Intl. Seaweed Symp., Pergamon, p. 248-254.

____________. 1965. Imperial Beach, Kelp Habitat Imp. Proj., Ann. Rpt., 1964-65, Calif. Inst. Tech., Pasadena, p. 33-41.

____________(ed.). 1971a. The biology of giant kelp beds (*Macrocystis*) in California. Beihefte Nova Hedwigia 32: 1-600.

__________. 1971b. The biology of giant kelp beds (*Macrocystis*) in California: Introduction and background. Nova Hedwigia, Suppl. 32, Cramer: 1-97.

__________and C. L. Hubbs. 1968. (Ed.) Utilization of kelp bed resources in Southern California. Dept. Fish and Game, Fish Bull. 139: 264 p.

__________, G. C. Stephens, and B. B. North. 1970. Marine algae and their relations to pollution problems. FAO Tech. Conf. Poll., MP/70/R-8, 1-22.

O'Connell, C. P. 1953. The life history of the cabezone, *Scorpaenichthys marmoratus* (Ayers). Calif. Dept. Fish and Game Fish. Bull., 93: 1-76.

__________. 1972. The interrelation of the biting and filtering in the feeding activity of the northern anchovy (*Engraulis mordax*). J. Fish. Res. Bd. Canada. 29: 285-293.

__________and J. R. Zweifel. 1972. A laboratory study of particulate and filter feeding of the Pacific mackerel *Scomber japonicus*. Fish. Bull. 70(3): 973-981.

Odell, D. K. 1970. Premature pupping in the California sea lion. Proc. Seventh Ann. Conf. Biol. Sonar Diving Mamm., Stanford Research Inst. p. 185-190.

__________. 1971. Censuses of pinnipeds breeding on the California Channel Islands. J. Mamm. 52: 187-190.

__________. 1972. Studies of the biology of the California sea lion and the northern elephant seal on San Nicolas Island, California. Dissertation. Dept. Zoology, Univ. of Calif., Los Angeles.

Odum, W. E., G. M. Woodwell, and C. G. Winsten. 1969. DDT residue absorbed from organic detritus by fiddler crabs. Science 164: 576-77.

Okubo, K. and T. Okubo. 1962. Study on the bioassay method for evaluation of water pollution, Part 2: Use of fertilized sea urchins and bivalves. Bull. Tokai Reg. Fish. Res. Lab. 32: 131-140.

Oldroyd, I. S. 1924. The marine shells of the West Coast of North America, Geological Sciences. 1(1): 5-247.

Oliphant, M. S. 1973. California marine fish landings for 1971. Calif. Dept. Fish and Game, Fish Bull. 159: 49 p.

Orr, Robert. 1963a. Another record for the Pacific bottlenose dolphin. J. Mamm. 44(3): 424.

__________. 1963b. Interspecific behavior in pinnipeds. Paper given before the Soc. Mammalogists, Albuquerque, N. M.

__________. 1965. Interspecific behavior among pinnipeds. Zeitschrift Saugelierkunde 30: 163-171.

__________and T. C. Poulter. 1964. Northward movement of the California sea otter. Calif. Fish and Game 50(2): 122-124.

____________________. 1965. The pinniped population of Ano Nuevo Island, California. Proc. Calif. Acad. Sci. 32: 377-404.

____________________. 1967. Some observations of reproduction, growth and social behavior in the Steller sea lion. Proc. Calif. Acad. Sci. 35: 193-226.

Osborne, T. and J. G. Reynolds. 1971. California Seabird breeding ground survey 1969-1970. California Dept. of Fish and Game, Wildlife Management Branch Administrative Report No. 71-3 (January 1971). Sacramento, California.

Osburn, R. C. 1950. Bryzoa of the Pacific Coast of America. The Univ. of So. Calif. Pub., Allan Hancock Pac. Exped. Vol. 14 No. 1 Univ. of So. Calif. Press.

Paasche, E. 1967. Marine plankton algae grown with light-dark cycles. I. *Coccolithus huxleyi*. Physiol. Plant. 20: 946-956.

__________. 1968a. Marine plankton algae grown with light-dark cycles. II. *Ditylum brightwellii* and *Nitzschia turgidula*. Physiol. Plant. 21: 66-77.

__________. 1968b. The effect of temperature, light intensity and photoperiod on coccolith formation. Limnol. Oceanogr. 13: 178-181.

Palmer, T. S. 1904. Index Generum Mammalium. U. S. Dept. Agric. North American Fauna. No. 23.

Patten, Don. Mammals Division, Los Angeles County Museum.

Paxton, J. R. 1967a. A distributional analysis for the lanternfishes (family Myctophidae) of the San Pedro Basin, California. Copeia 1967(2): 422-440.

__________. 1967b. Biological notes on Southern California lanternfishes (family Myctophidae). Calif. Fish Game 53(3): 214-217.

__________. 1972. Osteology and relationships of the lanternfishes (family Myctophidae). Bull. L. A. Co. Mus. Natur. Hist. Sci. 13: 1-81.

Pequegnat, W. E. 1963. Population dynamics in a sublittoral epifauna. Pacific Sci. 17: 424-430.

________. 1964. The epifauna of a California siltstone reef. Ecology, 45(2): 272-283.

________. 1966. Distribution of epifauna biomass on a sublittoral rock-reef. Pacific Sci. 22: 37-40.

Peterson, R. S. 1968. Social behavior in pinnipeds. In R. J. Harrison, et al. (eds.), The behavior and physiology of pinnipeds. Appleton-Century-Crofts, p. 3-53.

________ and G. A. Bartholomew. 1967. The natural history and behavior of the California sea lion. Amer. Soc. Mamm. Spec. Publ. No. 1. 79 p.

________, B. J. LeBoeuf and R. L. DeLong. 1968. Fur seals from the Bering Sea breeding in California. Nature 219: 899-901.

Philbrick, R. N. 1967. Proceedings of the symposium on the biology of the California Islands. Santa Barbara Botanic Garden, Santa Barbara, California. 363 p.

Phillips, J. B. 1964. Life history studies on ten species of rockfish. Calif. Dept. Fish and Game Fish. Bull. 126: 1-

Pinkas, L. M. S. Oliphant, and I. L. K. Iverson. 1971. Food habits of albacore, bluefin tuna and bonito in California waters. Calif. Dept. Fish and Game Fish. Bull. 152: 1-105.

Poole, R. L. and M. W. Odemar. 1970. Calif. Fish & Game, M. R. R. ref. No. 70-15.

Poorman, Robert. Curator of mammals, marineland of the Pacific.

Portmann, J. E. 1970. A discussion of results of acute toxity tests with marine organisms, using a standard method. FAO Technical Conference on Marine Pollution and Its Effects on Living Resources and Fishing, 9-18 Dec. 1970, Rome Italy. FIR:MP/70/E-31.

Poulter, T. C. 1963a. Sonar signals of the sea lion. Science 139: 753-759.

________. 1963b. The sonar of the sea lion. IEEE Trans. Ultrasonic Engineering UE-10(3): 109-111.

________. 1964. The use of active sonar by the California sea lion *Zalophus californianus*. Submitted to J. Exper. Biol.

Quast, J. C. 1968a. Fish fauna of the rocky inshore zone, p. 35-55. In: North, W. G. and C. L. Hubbs (eds.). Utilization of kelp-bed resources in Southern California. Calif. Dept. Fish and Game Fish Bull. 139: 1-204.

———. 1968b. Estimates of the populations and the standing crop of fishes, p. 57-79. In: North, W. G. and C. L. Hubbs (eds.). Utilization of kelp-bed resources in Southern California. Calif. Dept. Fish and Game Fish Bull. 139: 1-204.

———. 1968c. Observations on the food and biology of the kelp bass *Paralabrax xlathratus*, with notes on its sportfishery at San Diego, California, p. 85-108. In: North, W. G. and C. L. Hubbs (eds.). Utilization of kelp-bed resources in Southern California. Calif. Dept. Fish and Game Fish Bull. 139: 1-204.

———. 1968d. Observations on the food of the kelp-bed fishes, p. 109-142. In: North, W. G. and C. L. Hubbs (eds.). Utilization of kelp-bed resources in Southern California. Calif. Dept. Fish and Game Fish Bull. 139: 1-204.

———. 1968e. The effects of kelp harvesting on the fishes of the kelp beds, p. 143-149. In: North, W. G. and C. L. Hubbs (eds.). Utilization of kelp-bed resources in Southern California. Calif. Dept. Fish and Game Fish Bull. 139: 1-204.

Radford, K. W., R. T. Orr and C. L. Hubbs. 1965. Reestablishment of the northern elephant seal (*Mirounga angustirostris*) off central California. Proc. Calif. Acad. Sci. (4th series) 31(1): 601-613.

Radovich, J. 1961. Relationships of some marine organisms of the Northeast Pacific to water temperatures particularly during 1957 through 1959. Calif. Dept. Fish and Game Fish Bull. 112: 1-62.

Rao, T. R. 1974. Influence of salinity on the eggs and larvae of the California killifish, *Fundulus parvipinnis*. Mar. Biol. 24(2): 155-162.

Rathbun, M. J. 1918. The Grapsoid crabs of America. U. S. Nat'l. Mus. Bull. 97. Govt. Printing Office, Washington, D. C. 461 p.

———. 1925. The spider crabs of America. Smithsonian Inst. U. S. N. M. Bull. 129. U. S. Govt. Printing Office. 613.

———. 1930. The ancroid crabs of America of the families Euryalidae, Portunidae, Atelecyclidae, Cancridae and Xantitidae. U. S. Govt. Printing Office, Washinton, D. C. Bull. 152. 609.

———. 1937. The oxystomatus and allied crabs of America. Nat'l. Mus. Bull. 97. Govt. Printing Office, Washington, D. C. 461.

Reid, F. M. H., E. Fuglister and J. B. Jordan. 1970. Phytoplankton taxonomy and standing crop. In J. D. H. Strickland (ed.), The ecology of the plankton off La Jolla, California, in the period April through September 1967. Scripps Inst. Oceanogr. Bull. 17: 51-661.

Reish, D. J. 1968. Marine life of Alamitos Bay. Forty-Niner Shops, Inc., Long Beach, Calif. 92 p.

__________. 1969. Discussion of the *Mytilus californianus* community on newly constructed rock jetties in Southern California. In Biology of the oceans, Belmont, Calif., Dickerson Pub., p. 18-28.

Repenning, C., R. S. Peterson and C. L. Hubbs. 1971. Antarctic Pinnipedia. Contributions to the systematics of the Southern Fur Seals, with particular reference to the Juan Fernandez and Guadelupe species. American Geophysical Union, p. 1-34.

Report of the Secretary of Commerce. Administration of the Marine Mammal Protection Act of 1972. December 21, 1972 to June 21, 1973. Prepared by the National Marine Fisheries Service, NOAA. Reprinted from Federal Register, Vol. 38, No. 147 - Wednesday, August 1, 1973.

Resig, J. M. 1961. Micor-plankton over the mainland shelf of Southern California. In R. E. Stevenson (ed.), The oceanography of the Southern California mainland shelf Vol. II. Microplankton and benthic marine flora. Los Angeles, Allan Hancock Found., USC.

Rett, E. Z. 1952. The northern elephant seal on San Miguel Island, California. J. Mamm 33(1): 109.

Rice, D. W. 1963. The whale marking cruise of the Sioux City off California and Baja, California. Norsk Hvalfanst-Tidende 6: 153-160.

__________ and V. B. Scheffer. 1968. A list of the marine mammals of the world. U. S. Fish and Wildlife Special Scientific Report - Fisheries No. 579. 16 p.

__________ and A. A. Wolman. 1971. The life history and ecology of the gray whale (*Eschrischtius robustus*). Special Publication No. 3. Amer. Soc. Mammal. 142 p.

Ricketts, E. F. and J. Calvin (fourth ed., revised by Joel W. Hedgpeth). 1968. Between Pacific Tides. Stanford, California: Stanford Univ. Press. xvi + 614 p., 8 col. pls., 302 figs.

Ridgway, S. H. 1972. Mammals of the sea. Biology and Medicine. S. H. Ridgway, ed., Charles C. Thomas, Springfield, Ill. p. 528-589.

__________ and M. D. Dailey. 1972. Cerebral and cerebellar involvement of trematode parasites in dolphins and their possible role in stranding. J. Wildl. Dis. 8: 33-43.

Riznyk, Raymond. 1974. Phytoplankton of the Southern California Bight area, a literature survey. Long Beach, California, Southern California Ocean Studies Consortium.

Ryther, J. H. 1969. Photosynthesis and fish production in the sea. Science 166: 72-76.

Sanders, H. L. 1960. Benthic studies in Buzzards Bay. III. The structure of the soft-bottom community. Limnol. Oceanogr. 5: 138-153.

___________. 1968. Marine benthic diversity: a comparative study. Amer. Natur. 102: 243-282.

___________. 1969. Benthic marine diversity and the stability-time hypothesis. Brookhaven Symp. Biol. 22: 71-81.

Sargent, M. C. and T. J. Walker. 1948. Diatom populations associated with eddies off Southern California in 1941. J. Mar. Res. 7: 490-505.

Saito, Y., and N. Nakamura. 1961. Biology of the sea hare, Aplysia juliana as a predator of the brown sea weed, Undaria pinnatifida. I. The feeding habit. Bull. Jap. Soc. Sci. Fish, Vol. 27, No. 5, p. 395-400.

Sandell, R. D. 1973. A comparative study of the food and feeding of the elasmobranch fishes in Anaheim Bay, California. M. A. Thesis, Long Beach, Calif., Calif. State Univ., 113 p.

SCCWRP. 1973a. The ecology of the Southern California Bight: Implication for water quality management. Ch. 7, Coastal fish populations, p. 193-203. TR 104: 1-531. El Segundo, Calif.

______. 1973b. Progress Rept. 12: 1-6. El Segundo, Calif.

______. 1973c. Baited camera observations of demersal fish. TM 207: 1-10. El Segundo, Calif.

Scheffer, V. P. 1950. Growth layers on the teeth of Pinnipedia as an indication of age. Science 112(2907): 309-311.

___________. 1958. Seals, sea lions and walruses. Stanford, Calif., Stanford Univ. Press, 179 p.

___________. 1962. Pelage and surface topography of the northern fur seal. U. S. Dept. Int. N. Am. Fauna No. 64. 92 p.

___________ and J. W. Slipp. 1948. The whales and dolphins of Washington State with a key to the cetaceans of the west coast of North America. Am. Midland Nat. 39: 257-337.

Schevill, W. E., W. A. Watkins and C. Ray. 1963. Underwater sounds of pinnipeds. Cience 141: 50-53.

Schmitt, W. L. 1921. The marine Decapod Crustacean of California. Univ. of Calif. Pub. in Zoology. 23: 1-470.

___________. 1940. The Stomatopods of the west coast of America. AHPE. 5(4): 129-225.

Schultz, G. A. 1966. Submarine canyons off So. Calif. IV. Systematics: Isopods. AHPE. 27(4): 1-56.

Seapy, R. R. 1974a. The distribution and abundance of the epipelagic mollusk *Carinaria japonica* in the waters off Southern California. Marine Biology: in press.

___________. 1974b. Zooplankton of Southern California, a literature survey, Long Beach, California, Southern California Ocean Studies Consortium.

Setchell, W. A. 1912. Algae novae et minus cognitae. Univ. Calif. Publ. Bot., 4, 229-268.

_____________. 1914a. The *Scinaia* assemblage. Univ. Calif. Publ. Bot. 6, 79-152.

_____________. 1914b. Parasitic florideae. Univ. Calif. Publ. Botany, 6, 1-34.

_____________and N. L. Gardner. 1920. The marine algae of the Pacific Coast of North America, Part 2. Chlorophyceae. Univ. Calif. Publ. Bot., 8, 139-381.

_____________________________. 1924. The marine algae. Expedition of the California Academy of Sciences to the Gulf of California in 1921. Calif. Acad. Sci. Proc. IV. 12, 695-949.

_____________________________. 1925. The marine algae of the Pacific Coast of North America. Part 3. Melanophyceae. Univ. Calif. Publ. Bot., 8, 383-898.

_____________________________. 1933. A preliminary survey of *Gigartina*, with special references to its Pacific North American species. Univ. Calif. Publ. Bot., 17, 255-340.

Sette, O. E. 1960. The long term historical record of meteorological, oceanographic and biological data. Calif. Coop. Oceanic Fish Invest. Rept. 7: 181-194.

Seymour, G. 1960. Furbearers of California. Calif. Dept. Fish and Game. 55 p.

Shannon, C. E. and W. Weaver. 1963. The mathematical theory of communication. Urbana, Ill.: Univ. Illinois Press.

Shepard, F. P. and K. O. Emery. 1941. Submarine topography off the California coast: Canyons and tectonic interpretations. Geol. Soc. Amer. Spec. Pap. 31: 171 p.

Silva, P. C. 1951. The genus *Codium* in California, with observations on the structure of the walls of the utricles. Univ. Calif. Publ. Bot., 25, 79-114.

__________. 1957. Notes on Pacific marine algae. Madrono 14, 41-51.

Siverthorne, W. and P. E. Sorense. 1971. Marine algae as an economic resource. Marine Tech. Soc. 7th annual Conf., 523-533.

Simpson, J. G. and W. G. Gilmartin. 1970. An investigation of elephant seal and sea lion mortality on San Miguel Island. Bioscience 20(5): 298.

Sims, R. H. 1974. Intertidal Macrophytes. In: Biological features of intertidal communities near the U. S. Navy sewage outfall, Wilson Cove, San Clemente Island, California. Ed. by Murray, S. N. and Littler, M. M. U. S. N. Tech. Pap. (In press).

Slawson, J. J. 1972. The abundance and seasonal fluctuations of cladocerans in Anaheim Bay and adjacent water. M. S. Thesis, Long Beach, Calif. State Univ.

Smith, A. W., C. M. Prato, W. G. Gilmartin, R. J. Brown and M. C. Keyes. 1974. A preliminary report on potentially pathogenic microbiological agents recently isolated from pinnipeds. J. Wildl. Dis. 10: 54-59.

Smith, C. L. and P. H. Young. 1966. Gonad structure and the reproductive cycle of the kelp bass, *Paralabrax clathratus* (Girard), with comments on the relationships of the serranid genus *Paralabrax*. Calif. Fish and Game 52(4): 283-292.

Smith, G. M. 1944. The marine algae of the Monterey Peninsula. Stanford University Press.

Smith, P. E. 1972. The increase in spawning biomass of northern anchovy, *Engraulis mordax*. Fish. Bull. 70(3): 849-874.

Soot-Ryen, T. 1955. A report on the family Mytilidae (Pelecypoda), AHPE. 20(1): 1-102.

Southern California Coastal Water Research Project. 1973. The ecology of the Southern California Bight: Implications for water quality management. El Segundo, California. 531 p.

Southward, A. J. 1958. The zonation of plants and animals on rocky shores. Biol. Rev., 33: 137-177.

Sowby, M. L. 1973. The seasonal abundance and distribution of decapod larvae in Anaheim Bay, California. M. S. Thesis, Calif. State Univ., Long Beach. 144 p.

Squire, J. L., Jr. 1972. Apparent abundance of some pelagic marine fishes off the Southern and central California coast as surveyed by an airborne monitoring program. Fish. Bull. 70(3): 1005-1019.

State Water Quality Control Board (California). 1965. An investigation of the fate or organic and inorganic wastes discharged into the marine environment and their effects on biological productivity. California State Water Quality Control Bd. Publ., 29. 116 p.

State Water Resources Control Board (California). 19?? A marine biological survey of central Orange County near three sewage outfalls.

Stephens, J. S., Jr. 1972. Bay and inshore fish, p. 18-21. In: Proc. So. Calif. Coastal Zone Symp., Fullerton, Calif., 17-18 March, 1972.

__________________. 1973. Inshore marine fish populations of the metropolitan Los Angeles area, p. 224 (Abstr.). Second Nat. Coastal and Shallow Water Res. Conf., Geogr. Progr., Office of Naval Research.

__________________, D. Gardiner and C. Terry. 1973. The demersal fish populations of San Pedro Bay, p. 148-166. In: Soule and Oguri (eds.), Mar. Stud. San Pedro Bay, Part II, Biol. Invest. Allan Hancock Found. Publ. USC - SG - 6 - 73.

__________________, R. K. Johnson, G. S. Key, and J. E. McCosker. 1970. The camparative ecology of three sympatric species of California blennies of the genus *Hypsoblennius* Gill (Teleostomi, Blenniidae). Ecol. Monogr. 40: 213-233.

__________________, C. Terry, S. Subber, and M. J. Allen. 1974. Abundance, distribution, seasonality, and productivity of the fish populations in Los Angeles Harbor, 1972-73, p. 1-42. In: Soule and Oguri (eds.), Mar. Stud. San Pedro Bay, Part IV, Environ. Field Invest. Allan Hancock Found. Publ. USC - SG - 6 - 72.

Stephenson, T. A. and Anne Stephenson. 1949. The universal features of zonation between tide marks on rocky coast. J. Ecol., 37(2): 289-305.

____. 1972. Life between tidemarks on rocky shores, W. H. Freeman Co.: 425 p.

Stevenson, R. E. and J. R. Grady. 1956. Plankton and associated nutrients in the waters surrounding three sewage outfalls in Southern California.

Strachan, A. 1970. Preliminary analysis of a white-water condition observed in the Fish Harbor-Los Angeles Yacht Club basin area, Los Angeles Harbor: November 1969 through January 1970. State Calif. Dept. Fish and Game, MRR Ref. No. 70-4.

Straughn, D. (ed.) 1971a. Biological and oceanographical survey of the Santa Barbara Channel oil spill 1969-1970. Vol. 1. Biology and bacteriology. 426 p. Allan Hancock Foundation, Univ. of So. Calif.

________. 1971b. Oil pollution and sea birds, p. 307-312. In S. Straughan (ed.) Biological and oceanographical survey of the Santa Barbara Channel oil spill 1969-1970. Vol. 1. Biology and bacteriology. Allan Hancock Foundation, Univ. of So. Calif.

Strickland, J. D. H. and T. R. Parsons. 1968. A practical handbook of seawater analysis. Bull. 167. Fish. Res. Bd. Can., Ottawa, Queens Printer, 311 p.

Sverdrup, H. U. and W. E. Allen. 1939. Distribution of diatoms in relation to the character of water masses and currents off Southern California in 1938. J. Mar. Res. 2: 131-141.

Thomas, W. H. 1972. Nutrients, chlorophyll, and phytoplankton productivity near Southern California sewage outfalls. IMR Ref. No. 72-19.

Thorson, G. 1950. Reproductive and larval ecology of marine bottom invertebrates. Biol. Revs. 25: 1-45.

________. 1957. Bottom communities (sublittoral or shallow shelf). Chapt. 17 in Treatise on marine ecology and paleoecology, Geol. Soc. Amer. Mem. 67, Vol. 1: 461-534, 20 figs.

Tomilin, A. G. 1957. Mammals of the U.S.S.R. and adjacent countries. Vol. IX. Translated from Russian, Israel Program for Scientific Translations. 1967. 717 p.

Torrey, H. B. 1904. The ctenophores of the San Diego region. Univ. Calif. Publ. Zool. 2(2): 45-51.

Trask, T. 1970. A study of three sandy beaches in the Santa Barbara, California area. In Biological and oceanographical survey of the Santa Barbara Channel oil spill, 1969-1970.

Tressler, D. K. 1923. Marine products of commerce. New York, Reinhold, 762 p.

Turner, C. H. and E. E. Ebert. 1962. The nesting of *Chromis punctipinnis* (Cooper) and a description of their eggs and larvae. Calif. Fish and Game 48(4): 243-248.

____________________and R. R. Given. 1964. An ecological survey of a marine environment prior to installation of a submarine outfall. Calif. Fish and Game, 50(3): 176-188.

________________________________. 1966. The marine environment in the vicinity of the Orange County sanitation districts ocean outfall. Calif. Fish and Game, 52(1): 28-48.

________________________________. 1968. The marine environment offshore from Point Loma, San Diego County. Calif. Fish and Game, Fish Bull. 140, 85 p.

________________________________. 1969. Man-made reef ecology. Calif. Dept. Fish and Game Fish Bull. 146: 1-221.

___________and A. R. Strachan. 1969. The marine environment in the vicinity of the San Gabriel rivermouth. Calif. Dept. Fish and Game, 55(1): 53-68.

Ulrey, A. B. and P. O. Greeley. 1928. A list of marine fishes (*Teleostei*) of Southern California, with their distribution. Bull. So. Cal. Acad. Sci. 28)1): 1-53.

University of California Institute of Marine Resources. 1970. Research on the marine planktonic food web at the Institute of Marine Resources. IMR Rept. No. 70-5.

Valentine, D. W. and R. Miller. 1969. Osmoregulation in the California killifish, *Fundulus parvipinnis*. Calif. Dept. Fish and Game 58(1): 20-25.

_____________ and M. E. Soule. 1973. Effect of p,p^1-DDT on developmental plasticity of pectoral fin rays in the grunion, *Leuresthes tenuis*. Fish Bull. 71(4): 921-926.

_____________________________, and P. Samollow. 1973. Asymmetry analysis in fishes: a possible statistical indicator of environmental stress. Fish. Bull. 71(2): 357-370.

Vedros, N. A., A. W. Smith, J. Schoenwald, G. Migaki and R. C. Hubbard. 1971. Leptospirosis epizzotic among California sea lions. Science 172: 1250-1251.

Wada, S. 1972. The ninth memorandum on the stock assessment of whales in the North Pacific. Unpublished report submitted to Scientific Committee, International Whaling Commission.

Wales, J. H. 1952. Life history of the blue rockfish, *Sebastodes mystinus*. Calif. Dept. Fish and Game 38(4): 485-498.

Walford, L. A. 1932. The California barracuda (*Sphyraena argentea*). Calif. Dept. Fish and Game Fish Bull. 37: 1-120.

Walker, B. W. 1952. A guide to the grunion. Calif. Dept. Fish and Game 38(3): 409-420.

Walker, W. A. Review of mortality, selectivity, and techniques of the live capture fishery for smaller cetaceans taken in Southern California waters for public display, 1966-1973. Paper presented at I. W. C. Sub-Committee, Scientific, April 12, 1974. Montreal, Canada.

__________. Research Associate, Marine Mammal Laboratory, Los Angeles County Museum.

Water Resources Engineers, Inc., 1965. Effects of digested sludge discharge on the ocean environment near the City of San Diego outfall. Report to the State Water Qual. Control Bd.

Watt, K. E. F. 1968. Ecology and resource management. New York, McGraw-Hill, Inc., 450 p.

White, F. N. and D. K. Odell. 1971. Thermoregulatory behavior of the northern elephant seal, *Mirounga angustirostris*. J. Mamm. 52: 758-774.

Whitlow, G. C., C. A. Chata and D. T. Matsuura. 1971. Behavorial control of body temperature in the unrestrained California sea lion. Comm. An. Behav. 6: 87-91.

Widdowson, T. B. 1971. Changes in the intertidal algal flora of the Los Angeles area since the survey by E. Y. Dawson in 1956-1959. Bull. Southern Calif. Acad. Sci., 70, p. 2-16.

Wiebe, P. H. 1970. Small-scale spatial distribution in oceanic zooplankton. Limnol. Oceanogr. 15(2): 205-217.

Wiley, G. W. 1970. The life history of the bluespot goby (*Coryphopterus nicholsi*). M. A. Thesis, Fullerton, Calif. State Univ., 39 p.

Wilke, F. 1959. Fat content of fur seal milk. Murrelet 39: 40.

Williams, G. C. 1957. Homing behavior of California rocky shore fishes. Univ. Calif. Publ. Zool. 59: 249-284.

Wilson, M. D. 1956. Quantitative survey of the benthic Mollusca of San Pedro Basin area, So. Calif. Masters thesis. Univ. So. Cal. 1-95.

Wintz, J. and K. Fauchald. 1970. Notes on some ophiuroids from the shelf off Santa Barbara. In Biological and oceanographic survey of Santa Barbara Channel oil spill, 1969-1970, Vol. 1: 149-158.

Woollacott and W. J. North. 1971. Bryozoans of Californian and Northern Mexico kelp beds. In The biology of giant kelp beds (*Macrocystis*) in California. Nova Hedwigia, Suppl. 32, Cramer: 455-479.

Wing, B. L. and K. A. Clendenning. 1959. Motile invertebrates of Macrocystis pyrifera fronds. Quarterly Progress Rept., 1 Oct.-31 Dec., 1958, Kelp Inv. Prog., Inst. Mar. Res., IMR Ref. 59-6, p. 4-18.

Yentsch, C. S. and D. W. Menzel. 1963. A method for the determination of phytoplankton chlorophyll and phaeophytin by fluorescence. Deep-Sea Res. 10: 221-231.

Young, R. E. 1972. The systematics and areal distribution of pelagic cephalopods from the seas off Southern California. Smithsonian Contrib. Zool., 97: 1-159.

APPENDIX 10

F. Important Marine Associated Habitats

1. Marshes, Bays, and Estuaries

Table F1-1

PRESENT CONDITION OF THE BAYS WITHIN THE REPORT AREA

(from Bradshaw & Mudie [1972], Purer [1942], Reish [1954], and Speth [1969]).

Name and Location	Man-made Physiographic Modification
Los Angeles County:	
Marina del Rey	substantial; relocated Ballona Creek and built marina
San Pedro Bay	substantial; relocated Los Angeles River and built Los Angeles-Long Beach Harbor
Alamitos Bay	substantial; relocated San Gabriel River and built marina
Orange County:	
Anaheim Bay*	partial; south-eastern stretch dredged for construction of marina and estuary dredged for harbor
Lower Newport Bay	substantial; relocated Santa Ana River and built harbor
Upper Newport Bay	minimal; construction of small dam and slightly dredged
San Diego County:	
San Mateo Creek+	partial; traversed by railroad and highway
Santa Marguerita River+	" " " "
San Luis Rey River+	" " " "
Loma Alta Creek+	" " " "
Buena Vista Lagoon++	" " " "
Aqua Hedionda Lagoon+	" " " "
Batiquitos Lagoon+	" " " "
San Elijo Lagoon+	" " " "
Del Mar Lagoon+	" " " "

Table F1-1

(Continued)

Name and Location	Man-made Physiographic Modification
San Diego County:	
Los Penasquitos Lagoon[+]	partial; traversed by railroad and highway
Mission Bay	substantial; relocated San Diego River and built marina
San Diego Bay	moderate; sludge accumulation and filling tidelands
Tijuana Estuary	minimal

*The areas designated as Anaheim Bay, Bolsa Bay and Huntington Harbour were once part of a large estuary having its opening to the sea at the present location of Anaheim Bay. They are considered here together as a coastal wetland complex.

+A sandbar forms across the mouth of the lagoon, breached only infrequently by high tides or flood waters during rainy season. Salinity may fluctuate between 2 °/oo or 55 °/oo.

++Completely separated from sea. Salinity low, ranging from 3 °/oo to 6.5 °/oo.

Table F1-2

NUMBER OF ALGAL SPECIES OCCURRING IN SOUTHERN CALIFORNIA EMBAYMENTS

(compiled from Reish, 1968; Turner & Strachan, 1969;
Frey, Hein & Spruill, 1970)

Locality	Green algae (Chlorophyta)	Brown algae (Phaeophyta)	Red algae (Rhodophyta)	Total
Alamitos Bay	3	5	9	17
San Gabriel River Mouth	3	1	15	19
Anaheim Bay	11	-	2	13
Newport Bay	5	4	11	20

Table F1-3

GENERALIZED DISTRIBUTION OF MARSH FORAMINIFERA ON THE PACIFIC COAST OF NORTH AMERICA

(after Phleger & Bradshaw, 1966)

<table>
<thead>
<tr><th>Species</th><th>Tidal Flat</th><th>Marsh Channel</th><th>Spartina Zone</th><th>Salicornia Zone</th></tr>
</thead>
<tbody>
<tr><td>Ammonia beccarii</td><td>xxxxxx</td><td>xxxxxx</td><td></td><td></td></tr>
<tr><td>Ammotium salsum</td><td colspan="2">xxxxxxxxxxxxxxx</td><td></td><td></td></tr>
<tr><td>Arenoparella mexicana</td><td></td><td></td><td>xxxxxx</td><td>xxxxxx</td></tr>
<tr><td>Discorinopsis aguayoi</td><td></td><td>xxxxxx</td><td>xxxxxx</td><td>xxxxxx</td></tr>
<tr><td>Elphidium spp.</td><td>xxxxxx</td><td>xxxxxx</td><td></td><td></td></tr>
<tr><td>Jadammina polystoma</td><td>xxxxxx</td><td colspan="3">xxxxxxxxxxxxxxxxxxxxxxxxxxxxx</td></tr>
<tr><td>Miliammina fusca</td><td>xxxxxx</td><td colspan="3">xxxxxxxxxxxxxxxxxxxxxxxxxxxxx</td></tr>
<tr><td>Textularia earlandi</td><td>xxxxxx</td><td></td><td></td><td></td></tr>
<tr><td>Trochammina inflata</td><td></td><td colspan="3">xxxxxxxxxxxxxxxxxxxxxxxxxxxxx</td></tr>
<tr><td>T. macrescens</td><td></td><td></td><td colspan="2">xxxxxxxxxxxxxxxxx</td></tr>
</tbody>
</table>

Table F1-4

NUMBER OF SPECIES OF THE THREE MOST STUDIED GROUPS OF INVERTEBRATE MACROBENTHOS KNOWN FROM SOUTHERN CALIFORNIA'S EMBAYMENTS

(compiled from various sources)

Locality	Polychaeta	Amphipoda	Mollusca
Los Angeles-Long Beach Harbor	69	11	54
Alamitos Bay	77	13	49
Anaheim Bay	76	7	54
Newport Bay	61	34	74
Mission Bay	?	?	19
San Diego Bay	17	?	25
Tijuana River Estuary	?	?	10

Table F1-5

RELATIVE ABUNDANCES OF COMMON POLYCHAETES OF SOUTHERN CALIFORNIA'S EMBAYMENTS, ARRANGED IN APPROXIMATE ORDER OF DECREASING IMPORTANCE

(modified from Kauwling & Reish, 1974)

Polychaetes	L.A.-L.B. Harbor	Alamitos Bay	Anaheim Bay	Newport Bay
Capitata ambiseta	+	**	**	**
Lumbrineris minima	+	*	+	*
Haploscoloplos elongatus	+	*	+	*
Capitella capitata	**	**	+	**
Cossura candida	**	*	**	**
Stauronereis rudolphi	*	**	+	**
Tharyx sp.	**	**	+	*
Prionospio cirrifera	+	+	**	*
P. b. newportensis	+	*	+	*
Armandia bioculata	+	+	*	*
Streblospio benedicti		**	**	+
Polydora spp.	+	*		+
Cirriformia luxuriosa	*	+	*	
Euchone limnicola		**	+	
Nerinides acuta		+	+	+
Neathes succinea		*	+	

** = major, * = important, + = present

Table F1-6

SPECIES COMPOSITION AND RELATIVE ABUNDANCE (%) OF MOLLUSKS IN MISSION BAY

(modified from Macdonald, 1969)

Species	Tidal Marsh Fauna	Tidal Creek Fauna
Gastropoda		
Acteocina culcitella	2.0	68.7
Assiminea translucens	68.6	+
Bulla gouldiana		+
Cerithidea californica	28.2	28.2
Littorina planaxis	+	
L. scutulata	+	
Melampus olivaceus	0.9	
Nassarius tegula		1.4
Siphonaria brannani		+
Pelecypoda		
Chione fluctifraga	+	0.6
C. undatella		*
Cryptomya californica		*
Macoma nasuta		*
Modiolus senhousei		0.6
Mytilus edulis	*	*
Lyonsia gouldii		+
Ostrea lurida	*	
Protothaca staminea		0.2
Tagelus californianus		0.3
Total individuals	2153	5462
Number of samples	100	78
Marsh area (km^2)	0.139	0.003

+ = present less than 0.1% individuals per site.

* = present at site but did not occur in samples.

Table F1-7

CONDITIONS OF THE FIVE ECOLOGICAL AREAS OF LOS ANGELES-LONG BEACH HARBORS

(modified from Reish, 1959)

Ecological Areas	Dominant sp. of Polychaete	Dissolved Oxygen (ppm) (mean)	Organic Carbon (%) (mean)
Healthy Bottom	Tharyx parvus Cossura candida Nereis procera	6.0	2.5
Semi-Healthy Bottom I	Polydora paucibranchiata Dorvillea articulata	3.2	2.0
Semi-Healthy Bottom II	Cirriformia luxuriosa	3.2	2.7
Polluted Bottom	Capitella capitata	3.5	2.7
Very Polluted Bottom	'No animals	2.2	3.4

Table F1-8

INVERTEBRATES ASSOCIATED WITH SAND DOLLAR (*Dendraster excentricus*) BEDS IN SAN DIEGO REGION

(compiled from Niesen, 1969)

Associated Species	La Jolla Shores	Mission Bay	San Diego R. Flood Channel	Tijuana Estuary
Anthozoa				
Harenactis attenuata	X			
Renilla kollikeri	X			
Stylatula elongata	X	X		
Zoalotus actius	X			
Gastropoda				
Astraea undosa		X		
Balcis sp.	X			
Bulla gouldiana			X	X
Conus californicus			X	
Kelletia kelletia		X		
Nassarius fossatus	X	X	X	X
Navanax inermis			X	X
Olivella biplicata	X	X	X	X
Polinices recluzianus	X	X	X	X
Pelecypoda				
Protothaca staminea			X	X
Siliqua patula				X
Tagelus californianus			X	X
Decapoda				
Callianassa californiensis			X	
Cancer spp.				X
Hemigrapsus oregonensis				X
Heterocrypto occidentalis				
Loxorhynchus cripsatus		X		
Portunus xantusii	X	X	X	X
Pachygrapsus crassipes		X		X
Asteroidea				
Astropecten armatus	X	X		
Patiria miniata		X		
Pisaster giganteus	X	X		
P. ochraceus		X		

Table F1-9

MAJOR FOOD ITEMS BY FREQUENCY (%) FOR THE SEVEN SPECIES OF TELEOSTS OCCURRING YEAR-ROUND IN ANAHEIM BAY (modified from Klingbeil, 1972)

Food Items	Calif. Killifish	Topsmelt	Shiner Perch	Staghorn Sculpin	Arrow Goby	Calif. Halibut	Diamond Turbot
Detritus		XXXX	X				
Algae		X					
Nematodes					XXX		
Polychaetes							XXXX
Oligochaetes					X		
Clam siphons							XXX
Ostracods	XX	XXXX			X		
Copepods	XX	X			XXXX		
Amphipods	XX	XX					
Cumaceans							X
Crabs				X			
Insects	XX						
Gobies						XX	
Zooplankton			XX				

XXXX = more than 80%

XXX = between 60 and 79%

XX = between 40 and 59%

X = between 20 and 39%

Table F1-10a

Major Attached Plants in Mugu Lagoon
From: MacGinitie and MacGinitie (1969).

- Thallophytes (algae)
  - *Enteromorpha intestinalis*
  - *Enteromorpha* sp.
  - *Rhizoclonium* sp.
  - *Ulva* sp.
- Spermatophytes (Flowering plants)
  - Water Plants
    - *Ruppia maritima*
    - *Zostera marina*
  - Marsh Plants *
    - Lower Marsh
    - *Frankeria* sp.
    - *Limonium* sp.
    - *Salicornia biglovi*
    - *Salicornia pacifica*
    - *Spartina* sp.
    - *Triglochin* sp.

* The identification of the marsh plants was furnished by John E. Warme. Dr. Warme has since published the following paper: Graded bedding in the recent sediments of Mugu Lagoon, California. Journ. Sedimentary Petrology, Vol. 37, No. 2, pp. 540-547, Figs. 1-4, June, 1967.

- Upper Marsh
  - *Atriplex* spp.
  - *Botis* sp.
  - *Distichlis* sp. (2 species)
  - *Salicornia rubra* or *S. depressa* (or both)

Table F1-10b

Animals of Mugu Lagoon
From: MacGinitie and MacGinitie (1969).

The following table gives an incomplete list of marine animals living within the lagoon. The numbers show at which station each is found and the letters indicate its abundance. The letter "A" indicates abundant; "C", common; and "R", rare. The card catalog of our survey of marine animals gives more detailed information on each species, including the reproductive seasons so far as known.

Invertebrates

	Abundance	Stations
Porifera (Sponges)	None	
Coelenterata (Sea anemones, jellyfishes, etc.)		
Anthopleura artemisia	C	1
Pachycerianthus aestuari	R	5, 6
Pelagia noctiluca (=P. panopyra)	R	3, 4
Ctenophora (Comb Jellies)		
Pleurobrachia bachei (Plankton Haul, 5-12-62)	A	3
Nemertea (Ribbon Worms)		
Cerebratulus californiensis	C	4,5,6
Sipunculoidea (Peanut Worms)		
Golfingia hespera	R	5,6
Echiuroidea (Sausage Worms)		
Listriolobus pelodes	C	2,3,4
Phoronida		
Phoronopsis viridis	R	5
Ectoprocta		
Membranipora membranacea (on floating seaweeds, rocks, etc.)	R	3,4,5
Annelida--Polychaeta (Annelid Worms)		
Axiothella rubrocincta	A	5,6
Chaetopterus variopedatus	C	5,6
Eupomatus gracilis	C	1
Halosydna brevisetosa	C	3,5,6
Hesperonoe complanata (with *Callianassa*)	C	5
Mesochaetopterus rickettsi	R	6
Neanthes brandti	C	5
Nephtys caecoides	C	5
Nereis eakini	R	3
Notomastus tenuis	A	1,3,5,6
Pareurythoe californica	C	5,6
Pectinaria californiensis	A	3,4
Phragmatopoma californica	R	1
Platynereis bicanaliculata	A	3
Polydora brachycephala	A	3
Polydora ligni	C	1

	Abundance	Stations
Echinodermata		
Asteroidea (Starfishes)		
Astropecten armatus	C	3
Echinoidea (Sea Urchins, Sand Dollars)		
Dendraster excentricus var. *elongatus*	A	4,5,6
Lytechinus pictus	C	3,5,6
Ophiuroidea (Brittle Stars)		
Amphipholis squamata	A	4
Holothuroidea (Sea Cucumbers)		
Leptosynapta albicans	C	6
Arthropoda--Crustacea		
Copepoda (Oar-footed Crustaceans)		
Clausidium vancouverense (on *Callianassa*)	A	5
Cirripedia (Barnacles)		
Balanus glandula	A	1-6
Balanus tintinnabulum californicus	A	1,2,3
Chthamalus fissus	A	1
Isopods ("similar feet")		
Livoneca vulgaris (on fishes)	C	1-7
Amphipods ("2 kinds of feet")		
Caprella angusta	A	5,6
Carides (Shrimps)		
Crago nigricauda	C	4,5,6
Hippolyte californiensis	A	5,6
Spirontocaris paludicola	A	5,6
Brachyura (True Crabs)		
Cancer antennarius	C	3,4
Cancer anthonyi	C	4
Cancer gibbosulus	C	4
Hemigrapsus oregonensis	A	1-7
Lophopanopeus frontalis	R	3,6
Pachygrapsus crassipes	A	1-6
Pyromaia tuberculata (= *Inachoides tuberculatus*)	R	5
Pinnixa faba	C	3,4,5
Pinnixa longipes	R	5
Speocarcinus californiensis	R	1

Table F1-10b (cont.)

Anomura (Hermit Crabs, etc.)		
Callianassa californiensis	A	1-7
Callianassa gigas (= C. longimana)	A	4,5,6
Upogebia pugettensis	R	6
Mollusca--Gastropoda (Univalves)		
Prosobranchia		
Acmaea limatula	C	3
Acmaea pelta	C	4
Acmaea persona	R	5
Acmaea scabra	R	3
Assiminea translucens	A	5
Astraea undosa	R	5
Cerithidea californica	A	1-6
Conus californicus	R	5,6
Crepidula lingulata	R	5,6
Crepidula onyx	A	4,5,6
Crepidula perforans	R	6
Forreria belcheri	R	5
Jaton festivus	R	5
Kelletia kelletti	R	5
Lacuna porrecta ?	C	5,6
Lacuna variegata	R	6
Mitrella carinata	C	4,5,6
Nassarius fossatus	C	5.6
Nassarius perpinguis	C	5,6
Olivella biplicata	C	4,5,6
Polinices lewisi	C	5,6
Polinices reclusiana	C	4,5,6
Sinum scopulosum	R	3
Thais emarginata	R	4
Opisthobranchiata		
Acteocina culcitella	C	5
Aplysia californica	R	6
Bulla gouldiana	A	1-6
Haminoea vesicula	R	5
Haminoea virescens	A	3,5,6
Hermissenda crassicornis	C	3,4
Navanax inermis	C	3,5,6
Phyllaplysia taylori	C	5,6
Pulmonata		
Melampus olivaceus	C	2
Mollusca--Pelecypoda (Bivalves)		
Prionodesmata		
Nuculana taphria	R	3,4
Pteriomorphia		
Aequipecten circularis	R	1,4,5,6
Leptopecten latiauratus	C	4,5,6
Lima hemphilli	R	3
Modiolus neglectus	C	1,3
Mytilus edulis	A	1-6
Ostrea lurida	C	3,5,6
Teleodesmata		
Chione californiensis	A	2-6
Clinocardium nuttalli	A	3,4,5,6
Cooperella subdiaphana	A	1-5
Cryptomya californica	A	1-6
Donax californica	R	1
Gari californica	R	1,2
Heterodonax bimaculatus	R	5,6
Hiatella arctica	C	3,4
Laevicardium substriatum	C	3,4,5,6
Lucinisca nuttalli	R	3,4
Macoma expansa	C	3,4
Macoma inconspicua	R	4
Macoma irus	R	3
Macoma nasuta	A	1-6
Macoma secta	A	3,4,5,6
Macoma yoldiformis	C	3,4,5,6
Mactra californica	C	4,5
Panopea generosa	R	5
Petricola carditoides	R	2,3
Platyodon cancellatus	R	3
Protothaca laciniata	C	3,4,6
Protothaca staminea	A	2-6
Psammotreta bicingulata	A	3,4,5,6
Sanguinolaria nuttalli	A	2-6
Saxidomus nuttalli	C	3,4,5,6
Semele incongrua	R	3
Siliqua lucida	R	3,4
Spisula catilliformis	R	4
Tagelus californianus	C	2,3,4,5
Tellina carpenteri	C	5,6
Tellina modesta	R	3
Transennella tantilla	R	3
Tresus nuttalli	C	1,3-6
Zirfaea pilsbryi	C	2,3
Anomalodesmata		
Lyonsia californica	C	3
Mollusca--Cephalopoda (Octopuses, squids)		
Octopus sp.	R	1,4,5
Mollusca--Amphineura (Chitons)		
Mopalia hindsi	R	3
Enteropneusta		
Unidentified species	R	5
Elasmobranchii (Sharks and Rays)		
Holorhinus californicus (Bat Ray)	C	3,4
Mustelus californicus (Grey smoothhound shark)	C	1,5
Rhinobatos productus (Shovelnose guitarfish)	C	1,3
Urobatis halleri (Round stingray)	A	1-3,5,6
Pisces (True Bony Fishes)		
Atherinops affinis (Bay smelt)	A	3
Clevelandia ios (Mudflat goby)	A	1-6
Cymatogaster aggregatus (Shiner)	C	3
Fundulud parvipinnis (Killifish)	C	5
Gillichthys mirabilis (Mudsucker)	C	2,3
Hypsoblennius gentilis (Red-throated blenny)	R	5
Hypsoblennius gilberti (Tidepool blenny)	R	3
Hypsopsetta guttulata (Diamond turbot)	C	3
Leptocottus armatus (Armed cabezon)	A	1-6
Platichthys stellatus (Starry flounder)	C	1,3
Roncador stearnsi (Spotfin croaker)	A	3
Scorpaenichthys marmoratus (Cabezon)	R	3
Syngnathus californiensis (Pipefish)	A	5,6

Figure F1-11. Seasonal abundance of phytoplankton in Quivira Basin, Mission Bay; ..... at 0.5-meter depth, ____ at 6-meter depth (after Fairbanks, 1969).

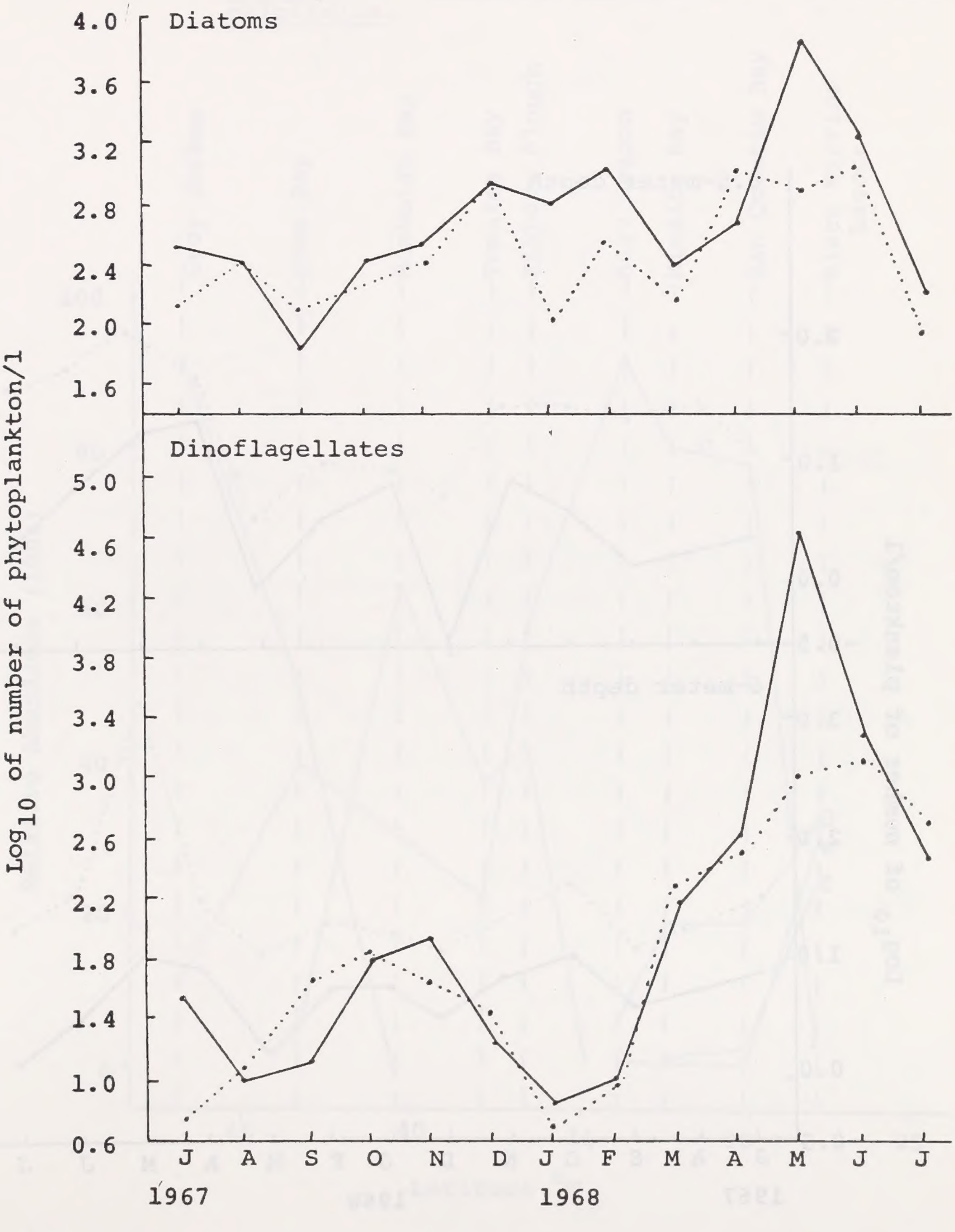


Figure F1-12. Seasonal abundance of zooplankton and adult copepods in Quivira Basin, Mission Bay; ..... total plankton, ________ copepods (after Fairbanks, 1969).

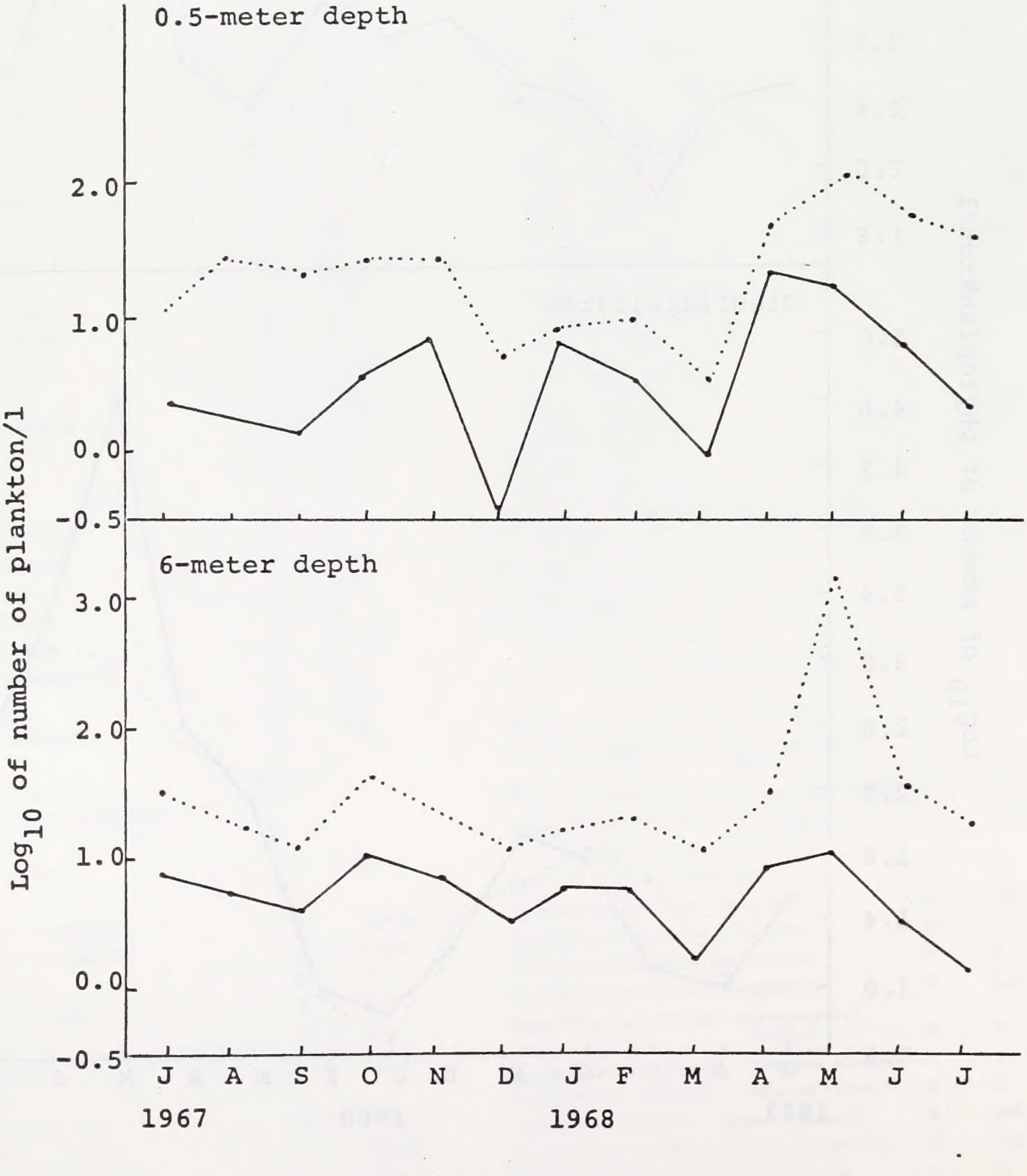


Figure F1-13. Latitudinal changes of relative abundance of six species of salt marsh mollusks on Pacific Coast of North America (after Macdonald, 1969). a = *Littorina newcombiana*, b = *Phytia myosotis*, c = *Assiminea translucens*, d = *Cerithidea californica*, e = *Melampus olivacens*, f = *Acteocina culcitella*.

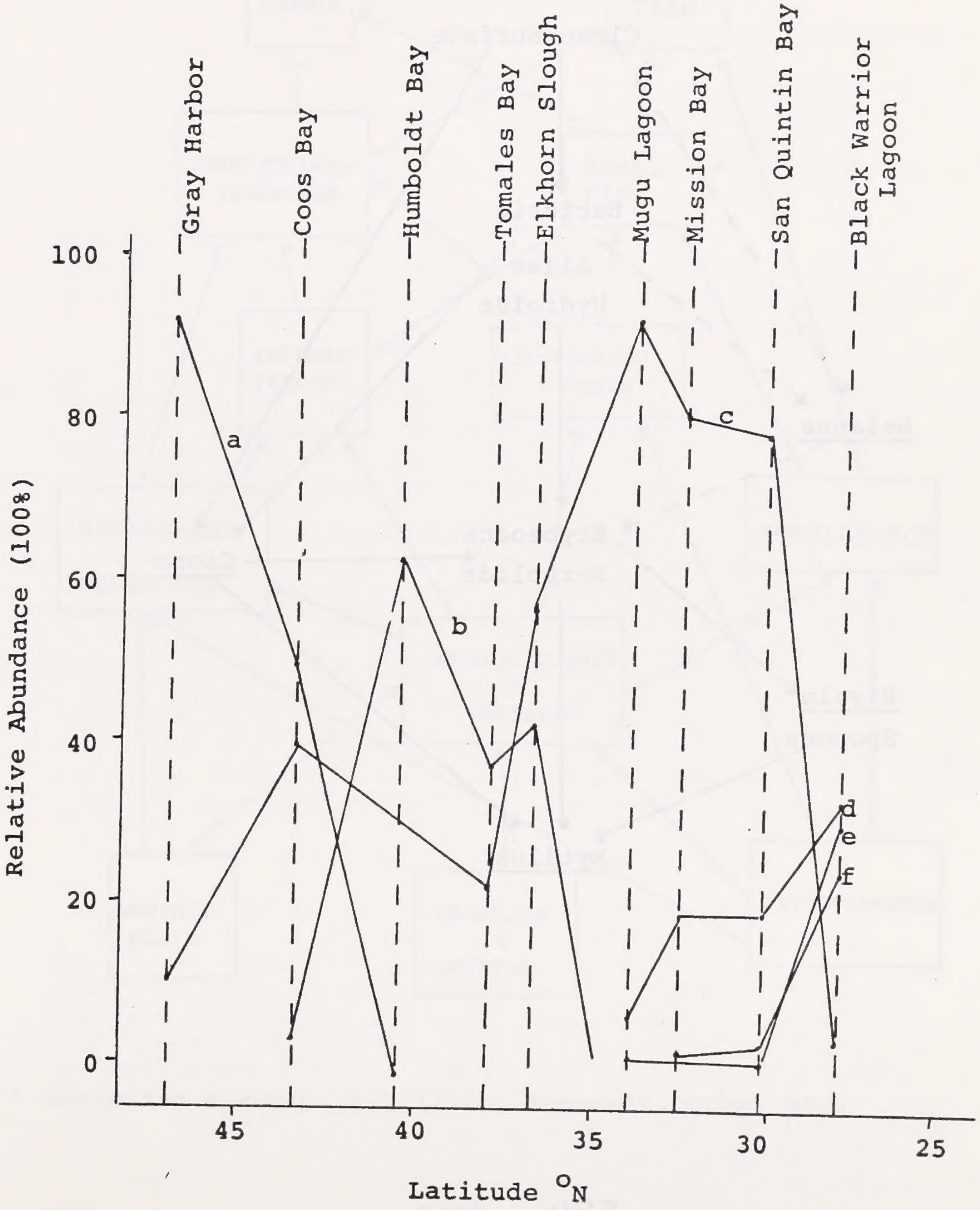


Figure F1-14. Sequence of dominant organisms as appeared on hard surfaces exposed in Newport Harbor (from Scheer, 1945).

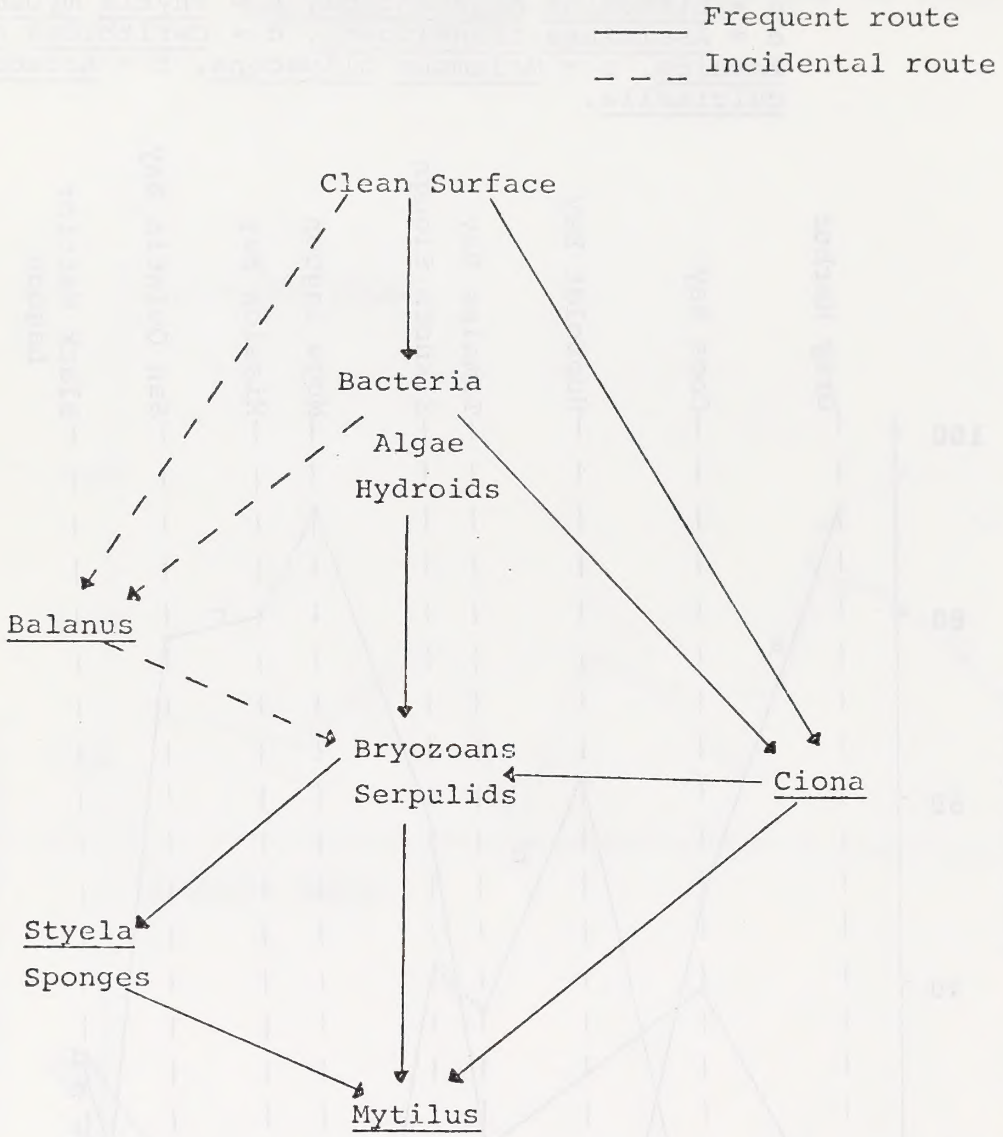
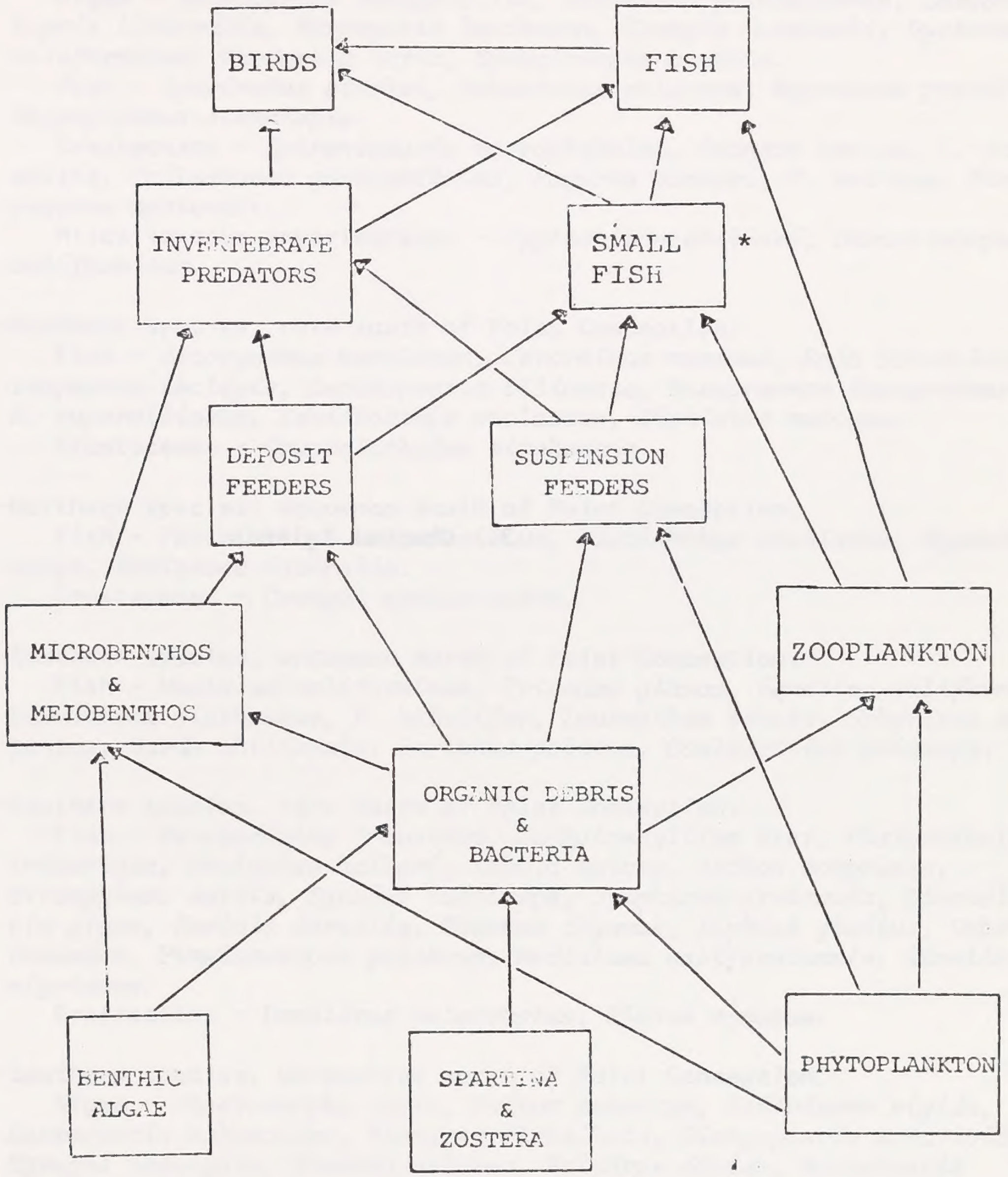


Figure F1-15. Generalized food web in the coastal embayments of Southern California (from various sources).



* including anchovy, killifish, topsmelt, goby, etc.

3. Channel Islands

Table F3-1

1. --Northern species, unreported south of Point Conception.
   Algae - *Macrocystis integrifolia, Postelsia palmaeformis, Lessoniopsis littoralis, Nerecystis leutkeana, Egregia menziesii, Dyctoneurum californicum, Rhodomela larix, Spongomorpha coalita.*
   Fish - *Spirinchus starksi, Sebastodes melanops, Hypomesus pretiosus, Hippoglossus stenolepis.*
   Crustaceans - *Spirontocaris macrophthalma, Crangon munita, C. variabilis, Callianassa goniophthalma, Pagurus tanneri, P. setosus, Parapagurus mertensii.*
   Miscellaneous Invertebrates - *Cyptochiton stelleri, Parastichopus californicus.*

2. --Northern species, rare south of Point Conception.
   Fish - *Notorynchus maculatum, Cetorhinus maximus, Raja binoculata, Isopsetta isolepis, Lepidopsetta bilineata, Hexagrammos decagrammus, H. superciliosus, Cebidichthys violaceus, Xiphister mucosus.*
   Crustaceans - *Cryptolithodes sitchensis*

3. --Northern species, uncommon south of Point Conception.
   Fish - *Psettichthys melanostictus, Platichthys stellatus, Hypsurus caryi, Embiotoca lateralis.*
   Crustaceans - *Crangon spinosissima.*

4. --Southern species, uncommon north of Point Conception.
   Fish - *Mustelus'californicus, Prionace glauca, Squatina californica, Paralabrax clathratus, P. nebulifer, Leuresthes tenuis, Sphyraena argentea, Sarda chiliensis, Seriphus politus, Caulolatilus princeps.*

5. --Southern species, rare north of Point Conception.
   Fish - *Heterodonius francisci, Cephaloscyllium uter, Platyrhinoidis triseriata, Urolophus halleri, Albula vulpes, Anchoa compressa, Strongylura exilis, Synodus lucioceps, Symphurus atricauda, Stereolepis gigas, Seriola dorsalis, Thunnus thynnus, Xiphias gladius, Umbrina roncador, Pimelometopon pulchrum, Medialuna californiensis, Girella nigricans.*
   Crustaceans - *Panulirus interruptus, Planes minutus.*

6. --Southern species, unreported north of Point Conception.
   Algae - *Chaetomorpha torta, Codium cuneatum, Coilodesme rigida, Desmarestia tabacoides, Dictyota flabellata, Dictyopteris zonarioides, Egregia laevigata, Eisenia arborea, Halidrys dioica, Macrocystis pyrifera, Pachydictyon coriaceum, Pelagophycus porra, Sargassum agardhianum, Taonia lennebackerae, Zonaria farlowii, Acrosorium uncinatum, Amphiroa zonata, Binghamia forkii, Botryocladia neushulii, Branchioglossum undulatum, Carpopeltis bushiae, Chondria nidifica, C. californica, Corallina gracilis, Cryptonemia angustata, Drouetia peltata, Gelidium nudifrons, Gigartina binghamiae, G. serrata, Gracilaria cunninghamii, Laurencia diegoensis, L. subopposita, Lithothamnium*

Table F3-1 (cont'd)

giganteum, Myriogramme caespitosa, Phyllophora clevelandii, Pogonophorella Californica, Prionitis cornea, Pterochondria pygmaea, Pterocladia pyramidale, Rhodymenia Arborescens, R. palmettifermis Sciadophycus stellatus, Scinaea johnstoniae.

Fish - *Gymnura marmorata, Anchoa delicatissima, Cetengraulis mysticetus, Cypselurus californicus, Gymnothorax mordax, Citharichthys xanthostigma, Hippoglossina stomata, Pleuronichthys ritteri, Paralabrax maculatofasciatus, Mugil cephalus, Makaira audax, Anisotremus davidsoni, Roncador stearnsi, Cheilotrema saturnum, Menticirrhus undulatus, Chromis punctipinnis, Hypsypops rubicunda, Scorpaena guttata, Porichthys myriaster.*

Crustaceans - *Pasiphaea emarginata, P. corteziana, Palaemon ritteri, Palaemonetes hiltoni, Urocaris infraspinis, Hyppolysmata californica, Spirontocaris lagunae, Alpheus barbara, A. californiensis, Synalpheus lockingtoni, Betaeus longidactylus, Crangon holmesi, Callianassa affinis, Paguristes parvus, Pylopagurus holmesi, Parlithodes californiensis, Munida hispida, Munidopsis histrix, M. aspera, Lepidops myops, Pachycheles holosericus, Cyclodorripe plana, Anasimus spinosus, Epialtus nuttalii, E. bituberculatus, Pugettia dalli, Pelia tumida, P. Clausa, Cancer amphioetus, C. anthonyi, Callinectes bellicosus, Cycloxanthops rugosus, Lophopanopeus frontalis, L. lockingtoni, Xanthias latimanus, Pilumnus spinohirsutus, Heteractaea lunata, Speocarcinus californiensis, Fabia lowei, Pinnixa barnharti, Parapinnixa affinis, Grapsodius eximius, Uca crenulata, Metamysidopsis elongata.*

Miscellaneous Invertebrates - *Renilla kollikeri, Lytechinus anamesus.*

7. --Insular endemic species.

Algae - *Egregia laevigata f. insularis, Pelagophycus giganteus.*

Fish - *Cymatogaster gracilis.*

Crustacea - *Pontonia californiensis, Periclimenes tenuipes, Spirontocaris brachydactyla, Nectocrangon californiensis, Pinnixa tomentosa, P. hiatus.*

* From Neustal, et al (1967)

Table F3-2

List of Endemic Plants of the Channel Islands*

	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara	Santa Catalina	San Clemente	San Nicolas
Brodiaea kinkiensis							X	
Triteleia clementina							X	
Eriogonum giganteum formosum							X	
Lithophragma maxima							X	
Astragalus nevinii							X	
Lotus argophyllus adsurgens							X	
Lotus scoparius traskiae							X	
Malacothamnus clementinus							X	
Camissonia guadalupensis clemetina							X	
Castilleja grisea							X	
Munzothamnus blairii							X	
Dissanthelium californicum						X	X	
Eriogonum giganteum					X	X		
Crossosoma californicum						X	X	
Astragalus traskiae					X			X
Lotus argophyllus ornithopus					X	X	X	X
Lupinus guadalupen							X	
Trifolium palmeri						X	X	X
Gilia nevinii						X	X	
Lomatium insulare							X	X
Linanthus pygmaeus pygmaeus							X	
Phacelia floribunda					X		X	
Phacelia lyonii						X	X	
Cryptantha traskiae							X	X
Lycium hassei						X	X	
Galvezia speciosa						X	X	
Scrophularia villosa						X	X	

Table F3-2 (cont'd)

	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara	Santa Catalina	San Clemente	San Nicolas
Galium catalinense catalinense						X	X	
Artemisia nesiotica						X	X	X
Eriophyllum nevinii					X	X	X	
Haplopappus canus							X	
Malacothrix foliosa					X		X	
Eriogonum arborescens		X	X	X				
Berberis pinnata insularis		X	X					
Erysimum insulare	X	X						
Dendromecon rigida harfordii		X	X					
Dudleya candelabrum		X	X					
Heuchera maxima		X	X	X				
Arctostaphylos insularis	X	X						
Phacelia divaricata insularis		X	X					
Solanum wallacei clokeyi		X	X					
Castilleja hololeuca	X	X	X	X				
Galium californicum miguelense	X	X						
Galium catalinense buxifolium	X		X					
Haplopappus detonsus		X	X					
Quercus tomentella		X	X			X	X	
Eschscholzia ramosa			X		X	X	X	
Dudleya greenei	X	X	X			X		
Jepsonia malvifolia		X	X			X	X	X
Lyonothamnus floribundus asplenifolius		X	X			X	X	
Astragalus miguelensis	X	X	X	X			X	
Ceanothus arboreus		X	X			X		
Ceanothus megacarpus insularis		X	X			X?	X?	

Table F3-2 (cont'd)

	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara	Santa Catalina	San Clemente	San Nicolas
Rhamnus pirifolia		X	X			X	X	
Lavatera assurgentiflora	X	X	X	X	X	X	X	
Amsinckia spectabilis nicolai	X						X	X
Mimulus flemingii		X	X	X		X	X	
Hemizonia clementina				X	X	X	X	X
Malacothrix indecora	X		X					X
Malacothrix insularis squalida		X	X	X	X			
Totals	10	23	23	8	10	24	41	10

*Compiled from Raven (1967)

Table F3-3

HERPETOFAUNAS OF THE CHANNEL ISLANDS*

	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara	San Nicolas	Santa Catalina	San Clemente
SALAMANDERS								
Aneides lugubris							X	
Batrachoseps pacificus	X	X	X	X			X	
Batrachoseps sp.			X					
FROGS								
Hyla regilla		X	X				X	
LIZARDS								
Uta stansburiana			X	X		X	X	X
Sceloporus occidentalis	X	X	X					
Klauberina riversiana					X	X		X
Eumeces skiltonianus							X	
Gerrhonotus multicarinatus	X	X	X	X			X	
SNAKES								
Thamnophis couchii							X	
Diadophis punctatus							X	
Coluber constrictor			X					
Lampropeltis getulus							X	
Pituophis melanoleucus			X				X	
Hypsiglena ochrorhyncha			X					
Crotalus viridis							X	
TOTALS	3	4	9	3	1	2	11	2

*from Savage (1967)

Table F3-4 —The distribution of the endemic avifauna of the Channel Islands, California. *

Species	Anacapa	Santa Cruz	Santa Rosa	San Miguel	Santa Barbara	Santa Catalina	San Nicolas	San Clemente	Subspecies on adjacent mainland[a]
California Quail (*Lophortyx californica*)	–	(intr.)	(intr.)	–	–	*catalinensis*	–	–	*californica*
Allen Hummingbird (*Selasphorus sasin*)	*sedentarius*	X[b]	X	–	–	X	–	X	*sasin*
Western Flycatcher (*Empidonax difficilis*)	*insulicola*	X	X	–	–	X	–	X	*difficilis*
Horned Lark (*Eremophila alpestris*)	*insularis*	X	X	X	X	X	X	X	*actia*
Scrub Jay (*Aphelocoma coerulescens*)	–	*insularis*	–	–	–	–	–	–	*californica*, *obscura*
Bewick Wren (*Thryomanes bewickii*)	*nesophilus*	X	X	–	–	*catalinae*	–	*leucophrys*	*correctus*
Loggerhead Shrike (*Lanius ludovicianus*)	*anthonyi*	X	X	–	–	X	–	*mearnsi*	*gambeli*
Orange-crowned Warbler (*Vermivora celata*)	*sordida*	X	X	X	X	X	–	X	*lutescens*
House Finch (*Carpodacus mexicanus*)	*frontalis*	X	X	X	*clementis*	X	X	X	*frontalis*
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	–	*megalonyx*	*clementae*	–	–	X	–	X	*megalonyx*
Rufous-crowned Sparrow (*Aimophila ruficeps*)	*obscura*	X	–	–	–	–[c]	–	–	*canescens*
Bell Sparrow (*Amphispiza belli*)	–	–	–	–	–	–	–	*clementeae*	*belli*
Song Sparrow (*Melospiza melodia*)	–	*clementae*[d]	X	*micronyx*	*graminea*[e]	–	–	*clementae*	*cooperi*
Total endemics:	7	10	9	4	4	9	2	10	

[a] Not necessarily the closest relative of the endemic insular form. See text page 312.
[b] X = the same subspecies occurs as is listed in the previous column.
[c] Not reported since 1863.
[d] a resident population may not be present on this island.
[e] Presumed extinct.

*(From Johnson 1972)

Table F3-5

Native Land Mammals*

	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara	Santa Catalina	San Clemente	San Nicolas
Adorned Shrew *(Sorex ornatus willetti)*						X		
Big-Eared Myotis *(Myotis evotis evotis)*			X			X		
Fringed Myotis *(Myotis Thysandes thysanodes)*								
California Myotis *(Myotis californicus spp.)*[1]		X	X			X	X	X
Big Brown Bat *(Eptesicus fuscus bernardinus)*			X					
Lump-nosed Bat *(Plecotus townsendii intermedius)*			X			X	X	X
Pallid Bat *(Antrozous pallidus pacificus)*			X			X		
Free-tailed Bat *(Tadarida brasiliensis mexicana)*			X				X	
Man *(Homo sapiens)*[2]	X	X	X	X	X	X	X	X
California Ground Squirrel *(Spermophilus beecheyi nesioticus)*						X		

1 Spp. of Northern Channel Islands *M.c.caurinus*, Southern Islands *M.c. californicus*,

2 Archaeological Artifacts from all of the islands indicate man's prehistoric presence.

Table F3-5 (Cont.)

	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara	Santa Catalina	San Clemente	San Nicolas
Big Eared Harvest Mouse *(Reithrodontomys magalotus spp.)*[3]			X			X	X	
Deer Mouse *(Peromyscus Maniculatus spp.)*[4]	X	X	X	X	X	X	X	X
Channel Islands Fox *(Uvocyon littoralis spp.)*[5]	X	X	X			X	X	X
Spotted skunk *(Spilogale gracilis amphialus)*		X	X					
Total 14	3	5	11	2	2	10	8	5

[3] Santa Catalina spp=*R.m.catalinae*, Santa Cruz spp=*R.m.santacruzae*
San Clemente spp=*R.m.longicaudus*.

[4] Eight insular subspecies are recorded.

[5] Six different endemic insular subspecies exist.

*Compiled from Von Bloeker (1967)

Table F3-6

Mammals of the Channel Islands

Introduced Land Mammals +

	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara	Santa Catalina	San Clemente	San Nicolas
European hare *(Lepus europaeus)*				X				
European rabbit *(Oryctolagus cuniculus)*					X			
harvest mouse *(Reithrodontomys megalotus)*							X	
meadow mouse *(Microdutus californicus)*							X	
black & roof rats *(Rattus rattus)*				X		X		
brown rat *(Rattus norvegicus)*						X		
house mouse *(Mus musculus)*						X		
dog *(Canis familiaris)*		X	X			X	X	X
house cat *(Felis catus)**	X	X	X	X	X	X	X	X
horse *(Equus caballus)***		X	X			X	X	
burro *(Equus asinus)**	X							
swine *(Sus scrofa)**		X	X			X		
dwarf elk *(Cervus nannodes)*		X						
snow deer *(Capreolus pyargus)*		X						
mule deer *(Odocoileus hemionus)*		X				X		
goats *(Capra hirca)**						X	X	
sheep *(Ovis aries)*	X		X			X	X	
buffalo *(Bison bison)*						X		
cattle *(Bos tauris)*		X	X			X		
Total 19	3	8	6	3	2	12	7	2

*Living in a feral (wild) state
**Living in a feral state on San Clemente

+Compiled from von Blocker (1967)

4. Mainland Terrestrial Biomes

Table F4-1. Amphibians and Reptiles of the Los Flores Site. From: Dames and Moore (1973).

Scientific Name[1]	Common Name	Habitat & Use Grassland	Riparian Woodland	Oak Woodland	Chaparral	Occurrence on Site Known (K) or Expected (E)	Possible (P) or Unlikely (U)	Relative Abundance on Site 20-23 Sept. 1973
CLASS AMPHIBIA: AMPHIBIANS								
ORDER CAUDATA: SALAMANDERS								
FAMILY AMBYSTOMIDAE: MOLE SALAMANDERS								
Ambystoma tigrinum	Tiger Salamander	N	N	N	N		P	
FAMILY SALAMANDRIDAE: NEWTS								
Taricha torosa	California Newt		N	N	N	E		
FAMILY PLETHODONTIDAE: LUNGLESS SALAMANDERS								
Ensatina eschscholtzi	Ensatina			B			P	
Batrachoseps attenuatus	California Slender Salamander		B	B		E		
Aneides lugubris	Arboreal Salamander			B			P	
ORDER ANURA: TOADS & FROGS								
FAMILY BUFONIDAE: TRUE TOADS								
Bufo boreus	Western Toad	N	N	N	N	E		
FAMILY HYLIDAE: TREEFROGS								
Hyla regilla	Pacific Treefrog	N	B	N		E		
CLASS REPTILIA: REPTILES								
ORDER SQUAMATA: LIZARDS & SNAKES								
SUBORDER LACERTILIA: LIZARDS								
FAMILY IGUANIDAE: IGUANIDS								
Sceloporus occidentalis	Western Fence Lizard		B	B	B	K		A
Uta stansburiana	Side-blotched Lizard	B	B	B	B	K		C
Phrynosoma coronatum	Coast Horned Lizard		B	B			U	
FAMILY SCINCIDAE: SKINKS								
Eumeces skiltonianus	Western Skink	B	B	B	B		P	
FAMILY ANGUIDAE: ALLIGATOR LIZARDS								
Gerrhonotus multicarinatus	Southern Alligator Lizard	B	B	B	B	E		
FAMILY ANNIELLIDAE: CALIFORNIA LEGLESS LIZARDS								
Anniella pulchra	California Legless Lizard		B	B	B		U	
SUBORDER SERPENTES: SNAKES								
FAMILY COLUBRIDAE: COLUBRIDS								
Coluber constrictor	Racer	B	B	B			P	
Masticophis flagellum	Coachwhip	B	B	B			P	
Pituophis melanoleucus	Gopher Snake	B	B	B	B	E		
Lampropeltis getulus	Common Kingsnake	B	B	B	B	E		
Thamnophis elegans	Western Terrestrial Garter Snake	B	B	B	B	E		
FAMILY VIPERIDAE: VIPERS								
Crotalus viridis	Western Rattlesnake	B	B	B	B	K		C

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[1] Nomenclature follows Stebbins, R.C., 1966.

B, Breeds, feeds, and rests in habitat.
N, Spends non-breeding season in habitat; feeds and rests there.
F, Feeds only, breeds and rests elsewhere.
K, Known; determined by on-site survey.
E, Expected or likely, but not verified.
P, Possible, but not likely.

A, Abundant
C, Common
R, Uncommon
* Fully Protected Species by California Department of Fish and Game.

Table F4-2. Mammals of the Los Flores Site.
From: Dames and Moore (1973)

Scientific Name[1]	Common Name	Habitat & Use: Grassland	Habitat & Use: Riparian Woodland	Habitat & Use: Oak Woodland	Habitat & Use: Chaparral	Occurrence on Site: Known (K) or Expected (E)	Occurrence on Site: Possible (P) or Unlikely (U)	Relative Abundance on Site 20-23 Sept. 197
ORDER MARSUPIALIA: MARSUPIALS								
FAMILY DIDELPHIDAE: OPOSSUMS								
Didelphis marsupialis	Common Opossum		B	B	B	E		
ORDER INSECTIVORA: INSECTIVORES								
FAMILY SORICIDAE: SHREWS								
Sorex ornatus	Ornate Shrew		B	B	B	E		
S. trowbridgii	Trowbridge Shrew		B	B		E		
FAMILY TALPIDAE: MOLES								
Scapanus latimanus	Broad-handed Mole	B	B	B		E		
ORDER CHIROPTERA: BATS								
FAMILY VESPERTILIONIDAE: EVENING BATS								
Myotis thysanoides	Fringed Myotis	Local distributions of bats are poorly known. These species are among the most likely, but it is doubtful whether more than two or three are seen with any degree of regularity.						
M. californicus	Calif. Myotis							
M. subulatus	Small-footed Myotis							
M. volans	Hairy-winged Myotis							
M. evotis	Long-eared Myotis							
M. yumanensis	Yuma Myotis	Feeding would be the most likely major activity with some possibly breeding in larger trees in riparian zone.						
Lasiurus cinereus	Hoary Bat							
L. borealis	Red Bat							
Eptesicus fuscus	Big Brown Bat							
Pipistrellus hesperus	Western Pipistrelle							
Antrozous pallidus	Pallid Bat							
Plecotus townsendi	Lump-nosed Bat							
FAMILY MOLOSSIDAE: FREE-TAILED BATS								
Tadarida brasiliensis	Brazilian Free-tailed Bat							
ORDER LAGOMORPHA: HARES & RABBITS								
FAMILY LEPORIDAE: HARES & RABBITS								
Lepus californicus	Black-tailed Hare	F		B	B	E		
Sylvilagus bachmani	Brush Rabbit				B	K		C
ORDER RODENTIA: RODENTS								
FAMILY SCIURIDAE: SQUIRRELS, GROUND SQUIRRELS. & CHIPMUNKS								
Otospermophilus beecheyi	Beechey Ground Squirrel	B		B		K		C
Eutamias merriami	Merriam Chipmunk			B	B		P	
Sciurus griseus	Western Gray Squirrel		B	B			P	
FAMILY GEOMYIDAE: POCKET GOPHERS								
Thomomys bottae	Valley Pocket Gopher	B	B	B	B	E		
FAMILY HETEROMYIDAE: POCKET MICE, KANGAROO RATS & MICE								
Perognathus californicus	Calif. Pocket Mouse				B	E		
Dipodomys agilis	Pacific Kangaroo Rat				B		P	
FAMILY CRICETIDAE: NEW WORLD RATS & MICE								
Reithrodontomys megalotis	Western Harvest Mouse	B		B	B	K		
Peromyscus californicus	Calif. Mouse			B	B	K		C
P. boylei	Brush Mouse				B	K		C
P. truei	Pinyon Mouse			B	B	K		C
P. maniculatus	Deer Mouse	B	B	B	B	K		A
Neotoma fuscipes	Dusky-footed Wood Rat		B	B	B	K		C
Microtus californicus	Calif. Meadow Mouse	B				E		

Table F4-2 (cont.) Mammals of the Los Flores Site.
From: Dames and Moore (1973).

Scientific Name[1]	Common Name	Habitat & Use Grassland	Riparian Woodland	Oak Woodland	Chaparral	Occurrence on Site Known (X) or Expected (E)	Possible (P) or Unlikely (U)	Relative Abundance on Site 20-23 Sept. 197
FAMILY MURIDAE: OLD WORLD RATS & MICE								
Rattus norvegicus	Norway Rat	Introduced, may occur					P	
R. rattus	Black Rat	near human habitation.					P	
Mus musculus	House Mouse						P	
ORDER CARNIVORA: CARNIVORES								
FAMILY CANIDAE: FOXES, WOLVES, & COYOTES								
Urocyon cinereoargenteus	Gray Fox	F	F	F	B	E		
Canis latrans	Coyote	F	F	F	B	K		C
FAMILY PROCYONIDAE: RACCOONS								
Procyon lotor	Raccoon		B	F	F		P	
*Bassariscus astutus	Ringtail		F		B		U	
FAMILY MUSTELIDAE: WEASELS, SKUNKS, ETC.								
Mustela frenata	Long-tailed Weasel	B	B	B	B		P	
Taxidea taxus	Badger	F	F	B	B		P	
Mephitis mephitis	Striped Skunk	F	B	F	F	E		
Spilogale putorius	Spotted Skunk	F	B	F	B		P	
FAMILY FELIDAE: CATS								
Felis concolor	Mountain Lion			F	F		P	
Lynx rufus	Bobcat	F	B	B	B	E		
ORDER ARTIODACTYLA: EVEN-TOED HOOFED MAMMALS								
FAMILY CERVIDAE: ELK, MOOSE, DEER, SHEEP, ETC.								
Odocoileus hemionus	Mule Deer	F	B	B	B	K		C

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[1] Nomenclature follows Ingles, L. G., 1965.

B, Breeds, feeds, and rests in habitat.
N, Spends non-breeding season in habitat; feeds and rests there.
F, Feeds only, breeds and rests elsewhere.
K, Known; determined by on-site survey.
E, Expected or likely, but not verified.
P, Possible, but not likely.

U, Unlikely, but possible.
A, Abundant.
C, Common.
R, Uncommon.
* Fully Protected Species by California Department of Fish and Game.

Table F4-3

AMPHIBIANS AND REPTILES OF BOLSA CHICA

Scientific Name	Common Name
Aniella pulchra	California legless lizard
Bufo boreas	Western toad (hypothetical inclusion)
Clemmys marmorata	Pacific pond turtle
Crotalus viridis	Western rattlesnake
Gerrhonotus multicarinatus	Foothill alligator lizard
Hyla regilla	Pacific tree frog
Lampropeltis getulus	Common king snake
Phrynosoma coronatum	Coast horned lizard
Pituophys melanoleucus	Gopher snake
Sceloporus occidentalis	Western fence lizard
Uta stansburiana	Side-blotched lizard

From: Dillingham Corp. (1971).

Table F4-4

MAMMALS OF BOLSA CHICA

Scientific Name	Common Name
Canis latrans	Coyote (Sighted in the past but not in 1970)
Didelphis marsupialis	Opossum
Felis domestica	Domestic cat
Lepus californicus	Black-tailed jack rabbit
Mephitis mephitis	Striped skunk
Microtus californicus	California vole
Mus musculus	House mouse
Mustela frenata	Long-tailed weasel
Peromyscus maniculatus	Deer mouse
Reithrodontomys megalotis	Western harvest mouse
Scapanus latimanus	Broad-footed mole
Sorex ornatus	Ornate shrew (hypothetical inclusion)
Spermophilus beecheyi	California ground squirrel
Sylvilagus audubonii	Desert cottontail
Sylvilagus bachmani	Brush rabbit
Taxidea taxus	Badger (Sighted in the past but not in 1970 survey)
Thomomys botta	Botta's pocket gopher
Urocyon cinereoargenteus	Gray fox (hypothetical inclusion)

From: Dillingham Corp. (1971).

REFERENCES

REFERENCES

Allan Hancock Foundation, University of Southern California. 1965. An oceanographic and biological survey of the Southern California mainland shelf. Calif. State Water Quality Control Board, Publ. 27: 232p.

American Ornithologists Union. 1957. Checklist of North American birds. In Dames & Moore, 1973.

Anonymous. 1950. A survey of San Diego Bay. U. S. Navy Volunteer Res. Reserve Unit 11-5, Prog. Rpt. No. 1, Dec., 1950. p. 2-21.

_________. 1952a. Los Angeles-Long Beach Harobr pollution survey. Calif., Los Angeles Reg. Water Pollut. Control Bd., No. 4, 43 p.

_________. 1952b. Report upon the extent, effects and limitations of waste disposal into San Diego Bay. Calif., San Diego Reg. Water Pollut. Control Bd., No. 9. 95 p.

_________. 1972a. Natural resources conservation program. Naval Weapons Station, Seal Beach, Calif. 60 p.

_________. 1972b. Environmental impact analysis for the San Elijo joint sewage system. Prepared for Environmental Development Agency, County of San Diego, by Atlantis Scientific. 231 p.

Baker, P. C. (in press). Plants of Anaheim Bay. The vascular plants of the salt marsh. In The marine resources of Anaheim Bay.

Bane, G. W. 1968. Fishes of the Upper Newport Bay. Mus. Systematic Biol., Univ. Calif., Irvine. Res. Series No. 3. 115 p.

Barnard, J. L. 1950. The occurrence of *Chelura terebrans* Philipi in Los Angeles and San Francisco Harbors. S. Cal. Acad. Scie. Bull. 49: 90-97.

_____________. 1952. The role of *Chelura* in the destruction of marine timbers. Marine Borer Conf., Port Hueneme, Calif., 1951. Rpt.:p1-p5.

_____________. 1953. On two new amphipod records from Los Angeles Harbor. S. Cal. Acad. Sci. Bull. 52: 83-87.

_____________. 1954. A new species of *Microjassa* (Amphipoda) from Los Angeles Harbor. S. Cal. Sci. Bull. 53: 127-130.

_____________. 1955. The wood boring habits of *Chelura terebrans* Philippi in Los Angeles Harbor. In Essays in the Natural Sciences honoring Captain Allan Hancock, Los Angeles, p. 87-88.

__________. 1958. Amphipod crustaceans as fouling organisms in Los Angeles-Long Beach Harbors, with reference to the influence of seawater turbidity. Calif. Dept. Fish and Game 44(2): 161-170.

__________. 1961. Relationship of Californian amphipod faunas in Newport Bay and in the open sea. Pacific Nat., 2: 166-186.

Barnard, J. L. and D. J. Reish. 1957. First discovery of marine wood-boring copepods. Science 125(3241): 236.

__________. 1959. Ecology of Amphipoda and Polychaeta of Newport Bay, California. Allan Hancock Found. Publ., Occasional Paper, No. 21, 106 p.

__________. 1960. Wood-browsing habits of the harpacticoid copepod *Tisbe gracilis* (T. Scott) in Southern California. Pacific Nat. 1(21-22): 9-12.

Bender, K. 1973. California least tern census and nesting survey, 1973. Calif. Dept. Fish Game Spec. Wildl. Prog. Rep., 47 p.

Bradshaw, John S. 1968a. Environmental parameters and marsh foraminifera. Limnol. & Oceanogr. 13(1): 26-38.

____________. 1968b. The biological and ecological relationships in the Los Penasquitos Lagoon and salt marsh area of the Torrey Pines State Park. Contract No. 4-05094-033, Rpt. prepared for the Calif. Div. Beaches and Parks.

Bradshaw, J. S. and P. J. Mudie. 1972. Some aspects of pollution in San Diego County Lagoons. Calif. Mar. Res. Comm., CalCOFI Rept. 16: 84-94.

Bright, D. 1974. Benthic invertebrates. Southern California Ocean Studies Consortium.

Bureau of Land Management. 1973. Environmental analysis, California oil & gas leasing program, advance copy. Sacramento, Calif, 303 p.

Brueau of Sport Fisheries and Wildlife. 1973. Threatened wildlife of the United States 1973 edition. Personal communication. Memorandum to Director BLM. 29 Aug. 1973, 289 p.

Bybee, James R. 1969. Effects of hydraulic pumping operations on the fauna of Tijuana Slough. Calif. Dept. Fish and Game 55(3): 213-220.

California Department of Fish and Game. 1951. San Diego Bay water pollution survey. Proj. No. 52-9-1. Rept. prepared for the San Diego Reg. Water Pollut. Control Bd.

________________. 1953. Biological survey: Lower Newport Bay. Rept. to Santa Ana Reg. Water Pollut. Control Bd. (Code No. 52-8-8). 329 p.

________________. 1973. Coastal county fish & wildlife resources and their utilization. Sacramento, California, August, 258 p.

________________. 1974. At the crossroads a report on California's endangered and rare fish and wildlife. 112 p.

California State Water Resources Control Board. 1972. Adoption of new water quality control plan for control of temperature in the coastal and interstate waters and enclosed bays and estuaries of California. Sacramento, Calif., 8 p. (mimeographed).

_________________________. 1972. Water quality control plan. Ocean waters of California. Sacramento, 13 p.

_________________________. 1973. Staff report on areas of special biological significance November 7, 1973. Sacramento 14 p. + figures (mimeographed).

_________________________. 1973. State water resources control board staff presentation for public hearings on areas of special biological significance December 21, 1973, Sacramento, California Jan 10, 1973, Los Angeles, California, Sacramento 8 p. (mimeographed).

_________________________. 1974. Areas of special biological significance designated by the State Water Resources Control Board March 21, 1974. 14 p. (mimeographed).

Carlberg, James M. 1970. An inventory of the flora and fauna of San Elijo Lagoon, with measurements of the physical and chemical parameters affecting their distributions. Cal. Dept. Fish and Game, Region 5, 79 p.

Carpelan, L. H. 1961. Salinity tolerance of some fishes of a Southern California lagoon. Copeia (1): 32-39.

________________. 1964. Effects of salinity on algal distribution. Ecology 45: 70-77.

Carriker, M. R. 1967. Ecology of estuarine benthic invertebrates: A perspective. In Estuaries, Amer. Assoc. Adv. Sci., p. 442-487.

Chapman, Gordon A. 1963. Mission Bay, a review of previous studies and the status of the sport fishery. Cal. Dept. Fish and Game 49(1): 30-43.

Chapman, V. J. 1960. Salt marshes and salt deserts of the world. N. Y., Interscience Publ., 392 p.

__________. 1964. Coastal vegetation. N. Y., Perogamon Press, The MacMillan Co., 245 p.

Cooper, J. C. 1870. The fauna of California and its geographical distribution. Proc. Ca. Acad. Sc:4:61-81.

Cox, M. C. 1969. The biology of the euryhaline water boatman *Trichocorixa reticulata* (Guerin-Meneville) (Hemiptera: Crorixidae). M. A. thesis, San Diego State Coll, 84 p.

Craig, A. M. 1971. Survey of California least tern nesting sites. Unpublished. California Department of Fish and Game, 112 p.

Dailey, M. S. 1974. Marine mammals of the Southern California coastal zone and offshore areas. Southern California Ocean Studies Consortium.

Dames & Moore. 1973. Selected studies of terrestrial and marine environments, proposed treatment facility and terminal. Canada Del Corral, Santa Barbara County, California, 164 p.

Damon, D. M. 1969. Population dynamics of coenobiodiscus and other plankton with respect to nutrient cycling in San Diego Bay, 1967-1968. M. S. thesis, San Diego State Coll., 135 p.

Daugherty, A. E. 1966. Marine mammals of California. Sacramento, California, California Dept. of Fish & Game, 86 p.

Davis, L. V. and I. E. Gray. 1966. Zonal and seasonal distribution of insects in North Carolina salt marshes. Ecol. Monogr., 36: 275-295.

Dawson, Carolyn. 1963. Benthic ecology in the entrance channel of Newport Bay, California. M. A. thesis, Univ. S. Calif., 121 p.

Diamond, J. 1969. Avifaunal equilibria and species turnover rates on the Channel Islands of California. Proc. Nat. Acad. Sci. 64: 57-68.

Dillingham Corporation. 1971. An environmental evaluation of the Bolsa Chica area. Volume II. Los Angeles, Signal Properties, Inc.

Dixon, R. L. and W. J. Eckmayer. (in press). A checklist of the elasmobranchs and teleosts inhabiting the outer harbor of the Seal Beach Naval Weapons Station. In The marine resources of Anaheim Bay.

Eckelbarger, K. J. and D. J. Reish. 1972. Effects of varying temperature and salinities on settlement, growth, and reproduction of the wood-boring pelecypod, *Lyrodus pedicellatus*. S. Cal. Acad. Sci. Bull. 71(3): 116-127.

Fairbanks, D. A. 1969. Environmental factors affecting phytoplankton populations in Mission Bay. M. S. thesis, San Diego State Coll. 136 p.

Felts, Raymond W. 1973. Seasonal distribution and abundance of the Chaetognatha from Anaheim Bay, California and the adjacent waters. M. S. thesis, CSU, Long Beach, 118 p.

Ford, R. S. 1968. Marine organisms of South San Diego Bay and the ecological effects of power station cooling water discharge. Rept. prepared for the San Diego Gas and Electric Co., San Diego.

Frey, H. W. 1971. Living marine resources of California. California State Department of Fish and Game.

Frey, H. W., R. F. Hein, and J. L. Spruill. 1970. Report on the natural resources of Upper Newport Bay and recommendations concerning the Bay's development. Calif. Dept. Fish and Game, Region 5, Rept., 68 p.

Fritz, E. S. (in press). The life history of the California killifish, *Fundulus parvipinnis* Girard, in Anaheim Bay, California. In The marine resources of Anaheim Bay.

Gorsline, D. S. 1967. Contrasts in coastal bay sediments on the Gulf and Pacific coasts. In Estuaries, Amer. Assoc. Adv. Sci., p. 219-225.

Gosner, Kenneth L. 1971. Guide to identification of marine and estuarine invertebrates. N. Y., Wiley-Interscience, 693 p.

Gress, F. 1970. Reproductive status of the California brown pelican in 1970, with notes on breeding biology and natural history. California Department of Fish and Game, Wildlife Management Branch Administrative Report No. 70-6: 21 p.

Gress, F., R. W. Risenbrough, D. W. Anderson, L. F. Kiff, and J. R. Jehl. 1973. Reproductive failure of double-crested cormorants in Southern California and Baja, California. Wilson Bulletin. 85: 197-208.

Grinnel, J., and A. H. Miller. 1944. The distribution of the birds of California. Pacific Coast. Avif. 27: 1-608.

Haaker, P. L. (in press). The biology of the California halibut, *Paralichthys californicus* (Ayres), in Anaheim Bay, California. In The marine resources of Anaheim Bay.

Hardy, R. A. 1970. The marine environment in Upper Newport and Sunset Bays, Orange County. Calif. Dept. Fish and Game.

Harper, C. A. 1971. Breeding biology of a small colony of Western Gulls (*Larus occidentalis wymani*) in California. Condor 73: 337-341.

Hartman, Olga. 1956. Quantitative survey of the Benthos of San Pedro Basin, Southern California. Part II, Final results and conclusions. Allan Hancock Found., Pac. Exped., 19: 186-456.

Hedgpeth, J. W. 1957. Biological aspects of estuaries and lagoons. Geol. Soc. Am., Mem., 67: 693-749.

Hope, W. D. 1971. The current status of the systematics of marine nematodes. In Proceedings of the First International Conference on Meiofauna, Smithsonian Contr. Zool., No. 76., 205 p.

Horn, M. H. 1974. Fishes. Southern California Ocean Studies Consortium.

Horvath, C. 1952. A study of the Teredinidae of the Los Angeles-Long Beach Harbors. Marine Borer Conf., Port Hueneme, Calif., 1951, Rept.:E1-E11.

Horvath, C., and Robert Menzies. 1951. The systematics, distribution, and seasonal settlement of marine wood-borers in Los Angeles and Long Beach Harbors. Proj. No. 52-4-6, State of Cal., Dept. of Natural Resources, Div. of Fish and Game.

Howell, A. B. 1917. Birds of the islands off the coast of Southern California. Pacific Coast Avifauna 12: 1-127.

Howey, Terry W. 1971. The occurrence and abundance of Copepoda in Anaheim Bay and the adjacent waters. M. S. thesis, CSU, Long Beach. 87 p.

Hubbs, C. L. 1967. A discussion of the geochronology of the California Islands. In R. N. Philbrick (ed.), Proceedings of the symposium on the biology of the California Islands. Santa Barbara Botanic Garden, Santa Barbara, California, p. 337-341.

Hulings, N. C. and J. S. Gray. 1971. A manual for the study of Meiofauna. Smithsonian Contr. Zool., No. 78, 83 p.

Hunt, G. L., Jr. and M. V. Hunt. 1974. Trophic levels and turnover rates: the avifauna of Santa Barbara Island. Condor (in press).

Ingles, L. G. 1965. Mammals of the Pacific States. In Dames & Moore, 1973, Stanford, California, Stanford Univ. Press.

Jehl, J. R. 1973. Studies of declining population of Brown Pelicans in N. W. Baja, California. Condor 75: 69-79.

Johnson, J. V. 1971. The annual growth and reproductive cycle of *Styela* sp. in the Marina del Rey, Venice, California. M. S. thesis, Dept. Zool., Univ. Nebraska.

Johnson, Martin W. and R. J. Menzies. 1956. Migratory habits of the marine gribble, *Limnoria tripunctata* Menzies, in San Diego Harbor, California. Biol. Bull. 110(1): 54-68.

Johnson, N. K. 1972. Origin and differentiation of the avifauna of the Channel Islands, California. Condor 74: 295-315.

Juday, Chauncey. 1907. Ostracods of the San Diego Region II. Littoral forms. Univ. of Calif., Publ. Zool. 3(9): 135-156.

Kauwling, T. J. and D. J. Reish. (in press). A quantitative study of the benthic polychaetous annelids of Anaheim Bay and Huntington Harbour, California. In The marine resources of Anaheim Bay.

Klingbeil, R. A. 1972. A comparative study of the food and feeding of the teleostean fishes in Anaheim Bay, California. M. A. Thesis, CSU, Long Beach, 129 p.

Klingbeil, R. A., R. D. Sandell, and A. W. Wells. (in press). An annotated checklist of the elasmobranchs and teleosts of Anaheim Bay. In The marine resources of Anaheim Bay.

Lackey, James B. 1967. The microbiota of estuaries and their roles. In Estuaries, G. H. Lauff, ed., Amer. Assoc. Adv. Sci., Publ. No. 83, p. 291-302.

Lackey, J. B. and K. A. Clendenning. 1965. Ecology of the microbiota of San Diego Bay, California. Trans. San Diego Soc., Nat. Hist. 14(2): 9-40.

Lane, E. D. (in press). Quantitative aspects of the life history of the diamond turbot, *Hypsopsetta guttulata* (Girard), in Anaheim Bay. In The marine resources of Anaheim Bay.

Lane, E. D. and C. W. Hill, (ed.) (in press). The marine resources of Anaheim Bay.

Laughrin, L. L. 1973. California Island Fox survey. California Dept. of Fish and Game, Wildlife Management Branch Administrative Report No. 73-3 (June 1973).

Leach, H. 1974. Personal communication. Calif. Dept. Fish and Game. Telephone conversations 3 January 1974; 2 April 1974.

Maillard, J. 1918. New records for some of the islands off the coast of Southern California Condor 20: 189-190.

McClendon, J. F. 1909. The ophiruans of the San Diego Region. Univ. Calif., Publ. Zool. 6(3): 33-64.

Macdonald, C. K. (in press). Notes on the family Gobiidae of Anaheim Bay. In The marine resources of Anaheim Bay.

MacDonald, K. B. 1969a. Quantitative studies of salt marsh mollusc faunas from the North American Pacific coast. Ecol. Monogr. 39: 33-60.

______________. 1969b. Molluscan faunas of Pacific coast salt marshes and tidal creeks. The Veliger 11: 399-405.

MacGinitie, G. E. 1939. Some effects of fresh water on the fauna of a marine harbor. Amer. Midl. Nat. 21: 681-686.

MacGinitie, G. E. and N. L. MacGinitie. 1969. A report on Mugu Lagoon. Tabulata. Santa Barbara Malacolog. Soc. 2(4): 14-24.

Mann, K. H. 1973. Seaweeds: Their productivity and strategy for growth. Science 182(4116): 975-981.

Marsh, G. Alex. 1973. The *Zostera* epifaunal community in the New York River, Virginia. Chesapeake Sci. 14(2): 87-97.

Martin, W. E. 1972. An annotated key to the Cercariae that develop in the snail, *Cerithidea californica*. Bull. S. Cal. Acad. Sci. 71(1): 39-42.

McLusky, Donald S. 1971. Ecology of Estuaries. London, Heinemann Educational Books ltd., 144 p.

Menzies, R. J. 1950. A remarkable new species of marine isopod, *Erichsonella crenulata* n. sp., from Newport Bay, California. S. Cal. Acad. Sci. Bull. 49: 25-35.

____________. 1951a. A new genus and new species of Asellote Isopod, *Caecijaera horvathi*, from Los Angeles-Long Beach Harbors. Amer. Mus. Novitates, 1542: 1-7.

____________. 1951b. A new species of *Limnoria* (Crustacea:Isopoda) from Southern California. S. Cal. Acad. Sci. Bull. 50: 86-88.

____________. 1952. *Limnoria* and the premature failure of creosoted marine structures in North America. Marine Borer Conf., Port Hueneme, Calif., 1951, Rept.:M1-M7.

____________. 1954. The comparative biology of reproduction in the wood-boring isopod crustacean *Limnoria*. Bull. Mus. Comp. Zool. 112(5): 364-388.

____________. 1958. The marine borer family Limnoriidae (Crustacea, Isopoda) Part I: Northern and Central America: Systematics, distribution, and ecology. Part II: Additions to the systematics. Bull. Mar. Sci. 7(2): 101-200.

Menzies, Robert J. and T. M. Widrig. 1955. Aggregation by the marine wood-boring isopod *Limnoria*. Oikos 6(2): 149-152.

Mohr, J. L. 1953. The relationship of the areas of marine borer attack to pollution patterns in Los Angeles-Long Beach Harbors. Marine borer Conf., 3rd, Coral Gables, Fla., 1952, Rept.:I1-15.

Mudie, P. J. 1970. A survey of the coastal wetland vegetation of San Diego Bay. Contract No. W26D25-51. Rept. prepared for the Calif. Dept. Fish and Game, 79 p.

Neushal, M., W. D. Clark, and D. W. Brown. 1967. Subtidal plant and animal communities of the Southern California Islands. In R. N. Philbrick (ed.), Proceedings of the symposium on the biology of the biology of the California Islands. Santa Barbara Botanic Garden, Santa Barbara, California, p. 37-55.

Niesen, Thomas M. 1969. Population structure, dynamics, breeding cycles and ecotypic variation in San Diego populations of the sand dollar, *Dendraster excentricus* (Eschscholtz). M. A. thesis, San Diego State Coll., 241 p.

North, W. J. 1971. The biology of giant kelp beds (*Macrocystis*) in California (ed.). Nova Hedwigia Suppl. 32, Cramer.

Odenweller, D. B. (in press). The life history of the shiner perch, *Cymatogaster aggregata* Gibbons, in Anaheim Bay, California. In The marine resources of Anaheim Bay.

Odum, E. P. and A. A. de la Cruz. 1967. Particulate organic detritus in Georgia salt marsh-estuarine ecosystem. In Estuaries, G. H. Lauff, ed., Amer. Assoc. Adv. Sci., Publ. No. 83. p. 383-388.

Orr, P. D. 1968. Prehistory of Santa Rosa Island. Santa Barbara, California, Santa Barbara Museum of Natural History, 233 p.

Orr, P. C. 1967. Geochronology of Santa Rosa Island, California. In R. N. Philbrick (ed.), Proceedings of the symposium on the biology of the California Islands. Santa Barbara, California, Santa Barbara Botanic Garden, p. 317-325.

Outwater, R. and J. Splansky. 1974. Land and water use. In A summary of knowledge of the Southern California coastal 3 zone and offshore areas. The Southern California Ocean Studies Consortium.

Painter, R. E. 1966. Zooplankton of San Pablo and Suisin Bays. Calif. Dept. Fish and Game, Fish Bull. 133: 18-39.

Pemberton, J. R. 1931. New records from the Channel Islands of Southern California. Condor 33: 218-219.

Philbrick, R. N. (ed.). 1967. Proceedings of the symposium on the biology of the California Islands. Santa Barbara, California, Santa Barbara Botanic Garden, 363 p.

Phleger, F. B. 1970. Foraminiferal populations and marine marsh processes. Limnol. & Oceanogr. 15(4): 522-534.

Phleger, F. B. and J. S. Bradshaw. 1966. Sedimentary environments in a marine marsh. Sci., 154(3756): 1551-1553.

Power, D. 1972. Number of bird species in the California Islands Evolution 26: 451-463.

Purer, E. A. 1942. Plant ecology of the coastal salt marshlands of San Diego County, California. Ecol. Monogr., 12: 81-111.

Qasim, S. Z. 1970. Some problems related to the food chain in a tropical estuary. In Marine food chains, J. Steele, ed., Berkeley and Los Angeles, Univ. Calif. Press, p. 45-51.

Quast, J. C. 1968. Estimates of the populations and the standing crop of fishes. In North, W. G. and C. L. Hubbs (eds.) Utilization of kelp-bed resources in Southern California. California Deptartment of Fish and Game Fish Bull. 139, p. 57-79.

Ranwell, D. S. 1972. Ecology of salt marshes and sand dunes. London, Chapman and Hall, 258 p.

Raven, P. H. 1967. The floristics of the California Islands. In R. N. Philbrick (ed.), Proceedings of the symposium on the biology of the California Islands. Santa Barbara, California, Santa Barbara Botanic Garden, p. 57-67.

Reish, D. J. 1954. Polychaetous annelids as associates and predators of the crustacean wood-borer, *Limnoria*. The Wasmann J. Biol. 12(2): 223-226.

___________. 1955. The relation of polychaetous annelids to harbor pollution. Public Health Rept. 70(12): 68-174.

___________. 1956. An ecological study of lower San Gabriel River, California, with special reference to pollution. Calif. Dept. Fish and Game, 42: 51-61.

___________. 1959. An ecological study of pollution in Los Angeles-Long Beach Harbors, California. Allan Hancock Found., Occasional Paper 22: 1-119.

___________. 1961a. A study of benthic fauna in a recently constructed boat harbor in Southern California. Ecology 42(1): 84-91.

___________. 1961b. The use of the sediment bottle collector for monitoring polluted marine waters. Calif. Dept. Fish and Game 47(3): 261-272.

__________. 1963. Mass mortality of marine organisms attributed to the "Red Tide" in Southern California. Calif. Dept. Fish and Game 49(4): 265-270.

__________. 1964a. Studies on the *Mytilus edulis* community in Alamitos Bay, California: I. Development and destruction of the community. The Veliger 6(3): 124-131.

__________. 1964b. Studies on the *Mytilus edulis* community in Alamitos Bay, California: II. Population variations and discussion of the associated organisms. The Veliger, 6(4): 202-207.

__________. 1965. Discussion of the *Mytilus californianus* community on newly constructed rock jetties in Southern California. The Veliger, 7(2): 95-101.

__________. 1968. Marine life of Alamitos Bay. 92 p.

__________. 1971a. Seasonal settlement of polychaetous annelids on test panels in Los Angeles-Long Beach Harbors, 1950-1951. J. Fish. Res. Bd. Can. 28: 1459-1467.

__________. 1971b. Effect of pollution abatement in Los Angeles Harbors. Mar. Pollut. Bull. 2(5): 71-74.

__________. 1972. Marine life of Southern California. 164 p.

Reish, D. J. and Howard A. Winter. 1954. The ecology of Alamitos Bay, California, with special reference to pollution. Calif. Dept. Fish and Game 40(2): 105-122.

Riley, G. A. 1967. The plankton of estuaries. In Estuaries, G. H. Lauff, ed., Amer. Assoc. Adv. Sci., Publ. No. 83, p. 316-326.

Rozaire, C. E. 1967. Archeological considerations regarding the Southern California Islands. In Proceedings of the symposium on the biology of the California Islands. R. N. Philbrick (ed.).

Russell-Hunter, W. D. 1970. Aquatic productivity. N. Y., The MacMillan Co., 306 p.

Ryther, J. H. and W. M. Dunstan. 1971. Nitrogen, Phosphorus, and eutrophication in the coastal marine environment. Science 171: 1008-1013.

Sandell, R. D. 1973. A comparative study of the food and feeding of the elasmobranch fishes in Anaheim Bay, California. M. A. thesis, CSU, Long Beach, 113 p.

Savage, J. M. 1967. Evolution of the insular herpetofaunas. In R. N. Philbrick (ed.), Proceedings of the symposium on the biology of the California Islands. Santa Barbara, California, Santa Barbara Botanic Garden, p. 214-227.

Scheer, Bradley Y. 1945. The development of marine fouling communities. Biol. Bull. 89: 103-121.

Shubin, Barbara A. (in press). Plants of Anaheim Bay. The algae. In The marine resources of Anaheim Bay.

Slawson, J. J. 1972. The abundance and seasonal fluctuation of cladocerans in Anaheim Bay and adjacent waters. M. A. thesis, SCU, Long Beach.

Smith, E. J., Jr. and T. H. Johnson. 1972. The marine life refuges and reserves of California. Marine Resources Information Bull. No. 1 Calif. Dept. Fish and Game, Sacramento, 14p + figures.

Snyder, Hnery G. 1965. Some larval fishes of Mission Bay, San Diego County, California. M. A. thesis, CSU, San Diego, 64 p.

Sowby, Michael L. 1973. The seasonal abundance and distribution of decapod larvae in Anaheim Bay, California, and adjacent water. M. A. thesis, CSU, Long Beach, 144 p.

Speth, John W. 1969. Status report on the coastal wetlands of Southern California as of February 1, 1969. Sacramento: Calif. Dept. Fish and Game, Wildlife Management, 29 p.

Stebbins, R. C. 1954. Amphibians and reptiles of western North America. In Dames & Moore, 1973. New York, McGraw-Hill.

Stevenson, R. E. and K. O. Emery. 1958. Marshlands at Newport Bay, California. Allan Hancock Found. Publ., Univ. S. Calif., Occasional Paper No. 20, 109 p.

Sweeney, Beatrice M. and Kenneth A. Clendenning. 1958. The phytoplankton of San Diego Bay. Quart. Progr. Rept., October 1-December, 1957, IMR ref. 58-2, p. 1-16.

Tasto, R. N. (in press). Aspects of the biology of the Pacific staghorn sculpin, *Leptocottus armatus*, in Anaheim Bay. In The marine resources of Anaheim Bay.

Teal, J. M. 1962. Energy flow in the salt marsh ecosystem of Georgia. Ecology 43: 614-624.

Thorson, Gunnar. 1957. Bottom communities (sublittoral or shallow shelf). In Treatise on marine ecology and papeoecology. Geol. Soc. Amer., Mem. 67: 461-534.

Townsend, W. 1968. Bird survey of San Nicolas Island. Condor 70: 266.

Turner, C. H. and A. R. Strachan. 1969. The marine environment in the vicinity of the San Gabriel River mouth. Calif. Dept Fish and Game 55(1): 53-68.

Valentine, J. W., and J. H. Lipps. 1967. Late Cenozoic history of the Southern California Islands. In R. N. Philbrick, (ed.), Proceedings of the symposium on the biology of the California Islands. Santa Barbara, California, Santa Barbara Botanic Garden, p. 21-35.

Vernberg, Winona B. and F. John Vernberg. 1972. Environmental physiology of marine animals. N. Y., Springer-Verlag, 346 p.

Vogl, R. J. 1966. Salt marsh vegetation of upper Newport Bay, California. Ecology 47: 80-87.

von Bloeker, J. C., Jr. 1967. The land mammals of the Southern California Islands. In R. N. Philbrick (ed.), Proceedings of the symposium on the biology of the California Islands. Santa Barbara, California, Santa Barbara Botanic Garden, p. 245-263.

Warme, J. E. 1971. Paleoecological aspects of a modern coastal lagoon. Univ. Calif. Publ. Geol. Sci., vol. 87, Berkeley, 110 p.

Weaver, D. W., and D. P. Doerner. 1967. Western Anacapia: a summary of the Cenozoic history of the northern Channel Islands. In R. N. Philbrick (ed.), Proceedings of the symposium on the biology of the California Islands. Santa Barbara, California, Santa Barbara Botanic Garden, p. 13-26.

Wieser, W. 1960. Benthic studies in Buzzards Bay. II: The Meiofauna. Limnol. & Oceanogr. 5: 121-217.

Williams, R. B., M. B. Murdock, and L. K. Thomas. 1968. Standing crop and importance of zooplankton in a system of shallow estuaries. Chesapeake Sci. 9(1): 42-51.

Zobell, C. E. and C. B. Felthm. 1942. The bacterial flora of a marine mud flat as an ecological factor. Ecology 23(1): 69-78.

APPENDIX 10

G. Human Utilization

2. Ocean Dumping and Military Use

Table G2-1. Summary of Ocean Dumping in the California Bight, 1931-1971. (From Brown, 1971)
Page 1 of three.

City	Type of Wastes	Disposal Operator	Waste Source(s)	Dumping History	Estimated Total Amount Dumped	Frequency of Dumping	Description of Dumping Grounds
Los Angeles	Containerized Wastes Industrial chemicals, solvents, laboratory (medical, industrial, academic), military and other unidentified wastes	California Salvage	Aircraft-aerospace, heat-treating, plating, film processing, chemical manufacturing & processing electronic instrument firms industrial, medical and academic laboratories, military & other unidentified sources	1947 to present	No data prior to 1965. 1965 to March[1] 1971: 11,574 drums & barrels[2] (636,570 gals.) (2648 tons) 1,331 containers 108,555 gallons (452 tons)[3] 1,245 boxes, cartons, cases, etc. 10 cylinders 112 bottles 30 filters 1,251 carboys (6255 gals.)[4] (26 tons) 20 pallets 1 refrigerator 1 freezer Undisclosed amounts of miscellaneous wastes	weekly	33°37'N 118°40'W cited in 1961, apparently never used 33°32'N 118°27'W cited in 1961 33°34'30"N 118°27'30"W cited in 1968 11.5 nautical miles SW of Pt. Fermin in 485 fathoms
	Industrial chemicals, etc. Misc. airplane parts, spoiled food & confiscated materials	H-10 Water Taxi Co., Ltd.	Same as above	1947 to present	6250 tons[5]	On demand	33°17'N 118°10'W 7.5 N.M. E of S. tip of Santa Catalina Island, Ca. 25.5 N.M. S. of San Pedro Light. 400 fathoms.
	Bulk Wastes Petroleum refinery wastes (spent caustics, acid sludges, etc.)	California Salvage Co.	Oil refineries	1946-61	3,000,000[6] barrels (42-gal.) (126,000,000 gals)[7] 524,160 tons	monthly	33°32'N 118°27"W San Pedro Channel 485 fathoms
				1961-present		quarterly	
	Oil drilling muds & cuttings	THUMS	Oil wells	1966-1970 (discontinued)	12,264,500[8] bbls. (42-gal.) (3,265,685 tons)[9]	daily	33°34'30"N 118°27'30"W 11.5 mi. SW of Pt. Fermin, 485 fathoms

Table G2-1 Summary of Ocean Dumping in The California Bight, 1931-1971. (continued) Page 2 of 3

City	Type of Wastes	Disposal Operator	Waste Source(s)	Dumping History	Estimated Total Amount Dumped	Frequency of Dumping	Description of Dumping Grounds	
Los Angeles (continued)	Bulk Wastes							
	Vessel refuse and garbage	H-10 Water Taxie Co., Ltd.	U.S. & foreign commercial vessels	1931 to present	52,000 tons[10]	weekly	33°17'N 118°10'W	7.5 N.M. E of S. tip of Santa Catalina Island. Ca. 25.5 N.M. S. of San Pedro Light. 400 fathoms. Proposed alternate site: 32°33'30"N 119°05'48"W about 37 miles SW (seaward) of San Clemente Island at 200 fathoms.
		U.S. Navy	**U.S. Naval & Coast Guard vessels**	1944-1970 (discontinued)	8100 tons[8]	weekly	20 N.M. SE of Santa Catalina Island (position doubtful)	
San Diego	Industrial chemicals (sodium cyanide)	Omar Rendering	Unidentified industrial firms	1960-67 (discontinued)	700 barrels	every 2 years	Explosives dumping ground 19 mi. W of Pt. Loma Light. 630 fathoms.	
	Filter cake (perlite cellulose)	Kelco Co.	Kelco Co.	1969-70 (discontinued)	346,480 tons[11]	every 2 days	32°37'N 117°24'W	1000 yards off a point 8 N.M. W of second entrance buoy to San Diego Bay. 65 fathoms.
	Vessel refuse and garbage	U.S. Navy	U.S. Naval vessels	1947-68 (discontinued)	98,700 tons[8]	twice weekly	Vicinity of Coronado Islands.	
Various military ammunition depots and other facilities	Unserviceable or obsolete munitions and toxic chemical ammunition	U.S. Navy U.S. Army U.S. Air Force	Military operations	1945-1970 (moratorium issued by Naval Dept. in 1971)	unknown	on demand	33°00'N 118°56'W	17 N.M. W of San Clemente Island, 100 square N.M. area, 5400 feet. Explosive dumping.
							32°45'N 117°37'W	20 N.M. W of Pt. La Jolla, 100 square N.M. area, 3600 feet. Explosive dump.
							32°45'N 117°37'W	20 N.M. W of Pt. Loma, 100 square N.M. area, 3600 feet. Explosive dumping (inactive).
							33°17'N 118°50'W	15 N.M. SW of Santa Catalina Island, 100 square N.M. area, 3000 feet. Explosives dumping (inactive).

Table G2-1 . Summary of Ocean Dumping in The California Bight, 1931-1971. (continued) Page 3 of 3

City	Type of Wastes	Disposal Operator	Waste Source(s)	Dumping History	Estimated Total Amount Dumped	Frequency of Dumping	Description of Dumping Grounds	
Southern California	Radioactive	AEC	Nuclear industry, laboratories, etc.	1946-68	3114 containers 107.88 curies	on demand	33° [illegible]0'N 119°33'W	21 N. M. S of Santa Cruz Island, 80 square N.M. area, 6300 feet. Chemical dumping (radioactive).
					not given		31°40'N 118°33'W	95 N.M. SW of Pt. Loma, 90 N.M. off Mexican coast, 6,000 feet. Chemical dumping (radioactive).
					not given		34°40'N 121°50'W	56 N.M. W of Pt. Arguello, 1125 square N.M. area, 12,000 feet. Explosives and toxic chemical ammunition (radioactive).
					4415 containers 33.6 curies		32°00'N 121°30'W	225 N.M. West of San Diego, 7200 feet. Chemical dumping (radioactive). Not shown on available charts

1. See attached table for complete breakdown of wastes for 1965-1971 period.
2. Tonnage on wet weight (8.32 lbs./gal.) basis for assumed 55-gallon capacity drums and barrels.
3. Tonnage on wet weight (8.32 lbs./gal.) basis.
4. Tonnage on wet weight (8.32 lbs./gal.) basis for assumed 5-gallon capacity carboy.
5. Based on reported disposal rate of 250 tone/year.
6. Three million-barrel estimate based on correspondence in Los Angeles Regional Water Quality Control Board files.
7. Tonnage on wet weight (8.32 lbs./gal.) for assumed 42-gallon barrel capacity.
8. Based on data provided in 1969 to the Bureau of Solid Waste Management Ocean Dumping Study.
9. Based on conversion factors provided by THUMS in 1969.
10. Tonnage based on reported disposal rate of 1200 tons/year.
11. Based on average reported wet weight tonnage of 1220-ton/trip x 284 total trips.

Table G2-2 Summary of Ocean Dumping in the California Bight 1965-1971* (from Brown, 1971)
Page 1 of 2

*Footnote

TYPE OF WASTE	SOURCE(S)	AMOUNT OF WASTE						
		Feb, July-Dec, 1965; Jan-June, Aug-Dec, 1966	Jan-Dec, 1967	Jan-Nov, 1968	Aug-Sept, 1969	Feb-Mar & Aug-Nov, 1970	Feb-Mar 1971	Total All Years
Identified Industrial Chemicals & Solvents								
Cyanide (copper, chromium, sodium, cadmium)	Aircraft, aerospace, heat treating, plating firms and other unidentified industrial operations	37 drums 31, 510 gallons 121 containers 3 boxes	38 drums 25, 843 gallons	282 drums 23, 515 gallons 162 boxes, cans, pieces and undisclosed amount of miscellaneous material	22 drums 3, 275 gallons	10 drums 7, 141 gallons 1 can 1 cylinder		389 drums 91, 264 gallons 121 containers 166 boxes, cans, pieces and undisclosed amount of miscellaneous material 1 cylinder
Beryllium wastes	Aircraft, aerospace, chemical, processing & manufacturing firms, military and other unidentified industrial operations	7 drums 20 containers 4 boxes	10 drums 14 containers 5 filters	20 drums 3 boxes 12 filters 10 gallons		32 gallons		37 drums 34 containers 7 boxes 17 filters 42 gallons
Magnesium	Aircraft, aerospace	19 drums 81 containers	47 drums	26 drums	23 drums			115 drums 81 containers
Waste acid	Academic institutions (universities, colleges, and high schools)	1 drum 17 boxes 127 containers 18 bottles	17 drums 13 boxes 93 containers 10 gallons	16 drums 42 boxes	2 drums	21 drums	3 drums 26 boxes 2 containers	60 drums 98 boxes 222 containers 18 bottles 10 gallons
Film Processing	Film Processing Labs.		391 drums	531 drums		18 drums		940 drums
Aluminum chloride	Chemical processing & manufacturing	24 barrels	4, 000 barrels 3, 100 gallons	3, 790 barrels 500 gallons				7, 814 barrels 3, 600 gallons
Unidentified Industrial Chemicals & Solvents	Electronics, aircraft, aerospace, chemical manufacturing and processing, industrial laboratories, instrument firms, and other unknown sources	34 drums 1, 430 gallons 609 containers 19 boxes 2 cylinders	1, 189 drums & barrels 1, 700 gallons 231 containers 762 boxes 2 cylinders 3 filters Undisclosed amount of miscellaneous	511 drums & barrels 8, 446 gallons 71 boxes 4 cylinders 1 filter 471 carboys Undisclosed amount of miscellaneous	42 drums 3 boxes 1 cylinder 109 carboys 10 pallets	215 drums & barrels 1, 935 gallons 39 cartons 9 filters 479 carboys 10 pallets 21 bottles	6 drums 9 containers 4 cartons 192 carboys 13 bottles 1 refrigerator 1 freezer	1, 997 drums & barrels 13, 511 gallons 849 containers 893 boxes and cartons 9 cylinders 13 filters 1, 251 carboys 20 pallets 34 bottles 1 refrigerator 1 freezer Undisclosed amount of miscellaneous

Table G2-2 Summary of Ocean Dumping in The California Bight (continued) Page 2 of 2

TYPE OF WASTE	SOURCE(S)	AMOUNT OF WASTE						
		Feb, July-Dec, 1965; Jan-June, Aug-Dec, 1966	Jan-Dec, 1967	Jan-Nov, 1968	Aug-Sept, 1969	Feb-Mar & Aug-Nov, 1970	Feb-Mar 1971	Total All Years
Identified Medical Wastes								
Acid and cyanide	Clinical Laboratory Pathology Laboratory Hospital	13 drums 10 containers	34 drums	51 drums 12 gallons 3 boxes	8 drums	24 drums 10 boxes	9 drums	139 drums 10 containers 12 gallons 13 boxes
Acids; other unknowns	Pathology Laboratory		36 gallons 60 bottles	60 gallons 28 boxes	25 boxes	2 drums	2 drums	4 drums 96 gallons 60 bottles 53 boxes
Unidentified Medical Wastes								
Hospital wastes	Various hospitals	4 containers	4 drums 1 box	11 drums		18 drums		33 drums 4 containers 1 box
Unidentified Military Wastes								
	USN, USAF	28 drums 10 containers		Undisclosed amount of miscellaneous containers		18 drums 9 boxes		46 drums 10 containers 9 boxes Undisclosed amount of miscellaneous containers
TOTAL ALL WASTES:		163 drums & barrels 982 containers 32,940 gallons 43 boxes & cartons 2 cylinders 18 bottles Undisclosed amounts of miscellaneous wastes	5,730 drums & barrels 338 containers 30,689 gallons 776 boxes & cartons 2 cylinders 60 bottles 8 filters Undisclosed amounts of miscellaneous wastes	5,238 drums & barrels 32,543 gallons 309 boxes, cartons, cases, & packages 4 cylinders 13 filters 471 carboys Undisclosed amounts of miscellaneous wastes	97 drums & barrels 3,275 gallons 28 boxes, cartons & packages 1 cylinder 109 carboys 10 pallets Undisclosed amounts of miscellaneous wastes	326 drums & barrels 9,108 gallons 59 boxes, cartons, cases & packages 1 cylinder 21 bottles 9 filters 479 carboys 10 pallets	20 drums & barrels 11 containers 30 boxes, cartons, etc. 13 bottles 192 carboys 1 refrigerator 1 freezer Undisclosed amounts of miscellaneous wastes	11,574 drums & barrels 1,331 containers 108,555 gallons 1,245 boxes, cartons, cases, etc. 10 cylinders 112 bottles 30 filters 1,251 carboys 20 pallets 1 refrigerator 1 freezer Undisclosed amounts of miscellaneous wastes

* Disposal Operator: California Salvage Company. Source: Los Angeles Regional Water Quality Control Board files.

3. Recreation and Allied Resources

Table G3-1

NUMERICAL RANKING OF THE 15 MOST IMPORTANT FISH IN VARIOUS TYPES OF SPORTFISHING IN SOUTHERN CALIFORNIA MARINE WATERS, 1963-1966 (from PINKAS, *et al.*,1968).

Rank	Species	Number	Percent comp.	Rank	Species	Number	Percent comp.
Party Boats (Annual Average, 1963-66)				Private Boats (1964)			
1.	Kelp and sand bass	1,207,996	30.2	1.	Pacific bonito	401,575	42.0
2.	Pacific bonito	897,335	22.0	2.	Kelp and sand bass	132,150	13.8
3.	Rockfish species	604,601	15.1	3.	California halibut	98,692	10.3
4.	California barracuda	530,688	13.3	4.	White croaker	84,641	8.8
5.	Sculpin	192,369	4.8	5.	Rockfish species	51,516	5.4
6.	Pacific mackerel	150,739	3.8	6.	Pacific mackerel	24,173	2.5
7.	California halibut	116,489	2.9	7.	Sculpin	21,025	2.2
8.	Albacore	103,748	2.6	8.	Halfmoon	19,879	2.1
9.	California yellowtail	45,834	1.2	9.	Black perch	19,558	2.0
10.	Halfmoon	35,202	0.9	10.	California barracuda	16,235	1.7
11.	California sheephead	34,970	0.9	11.	Queenfish	15,939	1.7
12.	White croaker	23,359	0.6	12.	Smelt,jack and top	5,936	0.6
13.	White seabass	12,109	0.3	13.	Albacore	5,902	0.6
14.	Ocean whitefish	10,608	0.3	14.	White seaperch	5,713	0.6
15.	Jack mackerel	10,161	0.3	15.	California yellowtail	4,926	0.5
	Subtotals	3,958,208	99.0		Subtotals	907,860	92.5
	Other fish	39,631	1.0		Other fish	73,600	7.5
	Grand totals	3,997,839	100.0		Grand totals	981,460	100.0

Table G3-1 (Continued)

Rank	Species	Number	Percent comp.	Rank	Species	Number	Percent comp.
Piers and Jetties (1963)				Open Coast (1965-66)			
1.	Queenfish	362,892	19.7	1.	Barred surfperch	85,743	36.4
2.	White croaker	342,002	18.5	2.	Opaleye	33,494	14.2
3.	Pacific bonito	283,068	15.3	3.	California corbina	29,644	12.6
4.	Walleye surfperch	141,151	7.7	4.	Black perch	25,413	10.8
5.	Shiner perch	132,968	7.2	5.	Walleye surfperch	12,405	5.3
6.	Smelt, jack and top	72,187	3.9	6.	Halfmoon	8,563	3.6
7.	Black perch	64,764	3.5	7.	Yellowfin croaker	4,190	1.8
8.	California halibut	56,933	3.1	8.	White seaperch	3,212	1.4
9.	Pacific mackerel	56,669	3.1	9.	Cabezon	2,743	1.2
10.	Kelp and sand bass	46,821	2.5	10.	Sargo	2,659	1.1
11.	Opaleye	31,448	1.7	11.	Pacific staghorn sculpin	2,412	1.0
12.	Northern anchovy	29,686	1.6	12.	Pile perch	2,389	1.0
13.	Barred surfperch	23,990	1.3	13.	Wrasses, unspecified	2,380	1.0
14.	White seaperch	17,769	1.0	14.	Sharks, unspecified	2,310	1.0
15.	California barracuda	17,351	0.9	15.	Kelp and sand bass	2,231	1.0
	Subtotals	1,678,699	91.0		Subtotals	219,788	93.3
	Other fish	166,271	9.0		Other fish	15,905	6.7
	Grand totals	1,844,970	100.0		Grand totals	235,693	100.0

Table G3-1 (Continued)

Rank	Species	Number	Percent comp.	Rank	Species	Number	Percent comp.
Inland Bays (1965-66)				Total All Southern California (Representative Annual Catch, 1963-66)			
1.	White croaker	93,278	35.1	1.	Pacific bonito	1,579,171	21.6
2.	Queenfish	47,228	17.8	2.	Kelp and sand bass	1,390,958	19.1
3.	Smelt, jack and top	17,518	6.6	3.	Rockfish species	661,220	9.1
4.	Kelp and sand bass	15,656	6.0	4.	California barracuda	565,166	7.7
5.	Pacific bonito	15,193	5.7	5.	White croaker	545,012	7.5
6.	Black perch	12,747	4.8	6.	Queenfish	426,592	5.8
7.	Spotfin croaker	11,695	4.4	7.	California halibut	280,369	3.8
8.	White seaperch	8,983	3.4	8.	Pacific mackerel	231,708	3.2
9.	California halibut	7,422	2.8	9.	Sculpin	220,129	3.0
10.	Turbots, unspecified	6,154	2.3	10.	Walleye surfperch	159,089	2.2
11.	Opaleye	5,344	2.0	11.	Shiner perch	133,386	1.8
12.	Perch unspecified	4,451	1.7	12.	Black perch	122,482	1.7
13.	Walleye surfperch	3,895	1.5	13.	Barred surfperch	113,599	1.6
14.	Pile perch	2,351	0.9	14.	Albacore	109,650	1.5
15.	Sargo	2,243	0.8	15.	Smelt, jack and top	96,809	1.3
	Subtotals	254,158	95.5		Subtotals	6,635,340	90.6
	Other fish	11,883	4.5		Other fish	690,663	9.4
	Grand totals	266,041	100.0		Grand totals	7,326,003	100.0

The following coastal county summary was taken from the California Department of Fish and Game (1973).

Santa Barbara County

Major Sport Areas: Santa Barbara, Ocean Beaches and Rocky Shores

Santa Barbara

The Santa Barbara Harbor entrance is protected on the north by a breakwater at Point Castillo and on the south by Stearns Wharf. The shoreline consists primarily of sandy beach with localized rocky portions.

Santa Barbara is a popular sportfishing center supporting both partyboats and skiffs that fish the surrounding areas. Partyboats operating out of the harbor journey to Point Arguello and the Channel Islands where blue, gopher, and yellowtail rockfish, kelp bass, Pacific bonito, barracuda, and Pacific mackerel are the major species caught. There are also boat launching facilities within the harbor for small skiffs. Skiff fishing is done primarily inside the large kelp beds along the coast or in the waters off Point Castillo. Skiff fishermen catch mainly bottomfish with bocaccio and chilipepper rockfish, and petrale and English sole, making up the bulk of the catch.

Some pier fishing is conducted along the commercial docks inside the harbor with perch making up the majority of the catch. Halibut are caught in the areas off the breakwater at the north end of the harbor.

Ocean Beaches and Rocky Shores

The Santa Barbara County coast and offshore waters provide a variety of sporting activities. Surf fishing, rock fishing, pier fishing, skindiving, SCUBA-diving, crabbing, lobster trapping, and spearfishing are all practiced along the coast. Surf fishing is enjoyed at most of the sandy beaches along the entire coastline. Gaviota State Beach, Goleta State Beach, Carpinteria State Beach, and El Refugio State Beach are popular surf fishing spots with barred surf perch being the major species caught.

Rock fishing is popular at Goleta Point, Carpinteria, and in the Indian Head Rock-Government Point area with cabezon being the major species landed. There is limited access to the shore from Purissima Point to Point Arguello and, hence, good rock fishing areas are literally untouched. Improved access would greatly increase the sporting opportunities in this and other areas.

The offshore waters of Santa Barbara County support large beds of giant kelp which serve as important habitats for a large number of fish and invertebrate species. There are piers with boat hoists for launching skiffs located at Gaviota and Goleta State Beaches and at Port Orford. Sport fishermen and commercial fishermen harvest abalone, lobster, and many species of fish, including kelp bass, California barracuda, California yellowtail, albacore, Pacific bonito, jack mackerel, sheephead and several species of rockfish from amongst the kelp beds. Commercial fishing for abalone is also undertaken in the waters off Purissima Point and Point Arguello. Sport fishermen launch their skiffs through the surf above Gaviota Beach State Park and enjoy crabbing, lobster trapping, and spearfishing.

Popular areas for skindiving and SCUBA-diving are Arroyo Burro State Beach, Coal Oil Point, El Capitan State Beach, Goleta Point, and Carpinteria. Carpinteria reef and the area off Carpinteria Beach are favorite spearfishing spots with opaleye, halfmoon, sheephead, and pile perch being the major species taken. Goleta Point is also another popular spearfishing site.

San Miguel Island

San Miguel Island, located 25 miles south of Point Conception Light House, is owned by the U.S. Navy and administered by the National Park Service. Landing is allowed only by special permit. The island has 24 miles of sandy beaches, scenic cliffs and sea caves. The shores are predominantly broken and rocky, but there are a few short stretches of sandy beach located between rocky outcroppings.

Skindivers take charter boats to this island to spearfish and dive. In 1970 divers harvested abalone, rock scallops, rockfish, kelp bass, and California sheephead from the waters surrounding the island. The catch was 0.88 fish and shellfish per diver-hour.

Santa Rosa Island

Santa Rosa Island is located about 27 miles southwest of Santa Barbara Harbor. The island is privately owned. The shoreline is predominantly high rock cliffs, but there is approximately 12 miles of sandy shoreline at the western end of the island.

Skindivers taking charter boats to this island harvested spiny lobster, abalone, rock scallop, rockfish, kelp bass, and California sheephead from its surrounding waters. The catch per diver-hour was 0.64 fish and shellfish in 1970.

Santa Cruz Island

Santa Cruz Island is about 22 miles south-southeast of Santa Barbara. It is the largest of the Channel Islands having approximately 60 miles of shoreline. The shores are high, steep, and rugged and are famous for the many sea caves found here. The island has numerous anchorages and landings. Sandy shoreline is found in pocket beaches along the eastern end of the island and in harbors along the northeastern side. The entire island is owned by two families, with permission from the owners being required for public landing.

Skindivers taking charter boats to this island harvest abalone, rock scallop, California sheephead, spiny lobster, kelp bass, and other species from the surrounding waters. The catch per diver-hour was 0.62 fish and shellfish in 1970.

Major Sport Species

Kelp and sand bass
Rockfish
Bonito
Barracuda
Mackerel
California halibut
Surf perch
Abalone
White seabass
Flatfish

Freshwater Angler Use

There are no significant inland fisheries in the coastal zone of Santa Barbara County.

Ventura County

Major Sport Areas: Ventura, Channel Islands Harbor, Port Hueneme; Ocean Beaches and Rocky Shores; and Offshore Islands

Ventura, Channel Islands Harbor, Port Hueneme

Ventura is located on Pierpont Bay about 18 miles south of Carpinteria; Channel Islands Harbor is located 8 miles south of Ventura; and Port Hueneme is located 5 miles south of Channel Islands Harbor. These three major sport areas have basically the same facilities within their harbors. Partyboats, skiff launching ramps, and a small craft harbor are present at each.

The partyboats fish locally and around the offshore islands with kelp bass, sand bass, rockfish, and California sheephead making up the bulk of the catch. Partyboats will also venture north to fish the waters off Rincon Point on occasion. The mainstay of the skiff fishery is also bottomfish with California sheephead, blacksmith, opaleye, kelp bass, sand bass, and rockfish being the major species caught. The small craft harbor at each center has two jetties protecting its entrance. Sportsmen fishing from the jetties land catches of perch, croaker, smelt, flatfish, and other miscellaneous species. There is a pier located near Ventura at San Buenaventura State Beach and another pier is located at Port Hueneme. These piers are heavily utilized by sport fishermen with barred surf perch making up the bulk of the catch.

Ocean Beaches and Rocky Shores

The Ventura County coast lends itself to a variety of sportfishing activities due to the many different habitats and species present. Surf fishing, rock fishing, clamming, skindiving, abalone diving, and spearfishing are all undertaken along the coast.

The coastal county and state parks of Ventura County are popular spots for surf fishing. County Park No. 5 (north of Seacliff), County Park No. 4 (south of Seacliff), County Park No. 3 (at Pitas Point), and San Buenaventura State Beach, Emma Wood State Beach, and McGrath State Beach are the more popular spots. The power plant outfall at Mandalay Beach provides warm water conditions which produce excellent barred perch fishing. There is considerable surf fishing potential from Laguna Point to Middle Point, but it is limited at present due to poor access. Good surf fishing is available at Point Mugu but again, poor access is limiting the use of the resource. Access is good between Point Mugu and Solromar and the rock fishing and surf fishing resource is greatly utilized in this area by sportsmen. Cabezon is the major species landed from the rocky shores while the barred surf perch is the major species landed from the beaches.

Pismo clam beds are located in the area of County Park No. 5 and on the beaches between Middle Point and Ormond Beach. County Parks Nos. 3 and 4 have some of the richest littleneck clam beds in the state. A reef under 12 feet of water and about one-half mile offshore from Pitas Point also contains very rich clam beds.

Skindiving, SCUBA diving, abalone diving, and spearfishing are all enjoyed by sportsmen between Bass Rock and the southern county border. Skin diving is popular along rocky shores or in areas where kelp beds are located close to shore. Spearfishing is also popular near the kelp beds since many different species of fish live in or near the kelp forests. Opaleye, halfmoon, black perch, and sheephead are the species most commonly speared.

Offshore Islands

Anacapa Island

Anacapa Island, actually a string of several small islands, is located approximately 15 miles southwest of Port Hueneme. The island is typified by seacliffs up to 500 feet high, with a few small rocky bays and insignificant sandy pocket beaches. Anacapa Island and Santa Barbara Island comprise the Channel Islands National Monument and are administered by the National Park Service. A ferry runs tourists to the islands periodically from Channel Islands Marina.

Skindivers taking charter boats to Anacapa Island harvest abalone, spiny lobster, rock scallop, California sheephead, and other species. In 1970 the catch per diver-hour was 0.66 fish and shellfish at Anacapa Island.

San Nicolas Island

San Nicolas Island is located 69 miles southwest of Los Angeles Harbor. It is a naval reservation and the water surrounding it is controlled by the Eleventh Naval District. The shoreline of the island is predominantly sandy beaches with a few rocky points.

Skindivers taking charter boats to the island harvest spiny lobster, abalone, California sheephead, and other species from surrounding waters. In 1970 the catch per diver-hour was 1.06, the highest in the Channel Islands.

Major Sport Species

Kelp and sand bass
Mackerels
Sheephead
Sculpin
Bonito
Rockfish
California halibut
Barracuda
White seabass
Surf perch

Freshwater Angler Use

Malibu Creek and Lagoon contain limited trout and warmwater game fishes. Use is about 100-200 angler days per year.

Los Angeles County

Major Sport Areas: Santa Monica Bay, Palos Verdes Peninsula, Long Beach, Santa Catalina Island and San Clemente Island

Santa Monica Bay Area

For this discussion, the Santa Monica Bay area includes the area from Point Dume to Redondo Beach. A sandy beach extends from Point Dume to Santa Monica pier and approximately 75 percent of this coastline is privately owned. The shoreline from Santa Monica pier to the northern margin of the Palos Verdes Peninsula consists of wide sandy beaches with developed backshore immediately behind the beach. All but one half mile of this shoreline is publicly owned and available for recreation. This vast area lends itself to a variety of sporting activities. Partyboat, skiff, pier, jetty, surf, rock, and spear fishing are all available. SCUBA diving, skindiving, clam digging, and kelp bed fishing are also very popular in this area.

Piers are located at Paradise Cove, Kellers Shelter, Santa Monica State Beach (municipal pier), Ocean Park, Dockweiler State Beach, Manhattan State Beach, Hermosa Beach, and Redondo Beach. Redondo Beach and Dockweiler State Beach also have facilities available for jetty fishing. The most prevalent species taken by pier and jetty fishermen are queenfish, white croaker, Pacific bonito, surf perch, California barracuda, topsmelt, and jacksmelt.

Partyboats operate out of Paradise Cove, Kellers Shelter, the Santa Monica State Beach area, and King Harbor near Redondo Beach. Some of the partyboats range farther from port than do the private skiffs and, with the aid of professional guides and a large live bait capacity, they pursue pelagic game species such as Pacific bonito, California barracuda, albacore, and California yellowtail. The partyboats fishing the kelp beds, reefs, and bottom areas land kelp and sand bass, California halibut, and various species of rockfish.

Skiffs may be rented or launched from Paradise Cove, Dockweiler State Beach, Marina Del Rey, and King Harbor near Redondo Beach. All of the private vessels have a high degree of mobility plus a fair live bait capacity, so the more experienced boatmen land good numbers of Pacific bonito, kelp and sand bass, California halibut, and several species of rockfish. Anglers with smaller boats are restricted to the nearshore and inland bays. The majority of their catch includes white croaker, halfmoon, and black perch.

The shore fishermen partake of both surf fishing and rockfishing in this area. Favorite surf fishing areas are Corral Beach, Amarillo Beach, Malibu Beach, Las Tunas State Beach, Topanga Beach, Will Rogers State Beach, Santa Monica State Beach, Ocean Park, Manhattan State Beach, Hermosa Beach, and Redondo Beach. Rockfishing is popular at Point Dume. Access is a limiting factor to surf fishing at Dockweiler State Beach and to rock and surf fishing in the area between Kellers Shelter and Carbon Beach. The shore fisherman's catch is characterized by the near-shore and surf-loving species such as white croaker, barred and other surf perch, opaleye, jack and topsmelt, queenfish, California corbina, and sharks. Pacific bonito are taken in fair numbers where they approach the shore or enter the sheltered bays.

SCUBA and other diving-oriented activities are undertaken in this area also. SCUBA-diving and lobster fishing are done at Point Dume. Abalone diving is practiced in Dume Cove, Paradise Cove, and off Escondido Beach and lobster, abalone, and rock scallops are obtained from the areas between Amarillo Beach and Malibu Beach. To the north of the Santa Monica Bay area, SCUBA-diving and skindiving are done off Sequit Point, and Pismo clam diving and halibut spearfishing are done between Lechuza Point and Point Dume.

Small kelp beds are located off Sequit Point and off Point Dume and Paradise Coves. Skiff fishermen, fishing in the vicinity of the kelp beds, land California barracuda and white seabass and kelp bass as the dominant species. Divers and spearfishermen generally like to work near kelp beds that are not too far from shore since they are easy to reach without a boat and the kelp attracts many different species of fish.

Littleneck clam beds are found on the shores of Malibu Lagoon State Beach. Clam diggers frequent this spot in numbers.

Palos Verdes Peninsula

This peninsula is located to the south of Santa Monica Bay and to the north of San Pedro Bay. The coastline is comprised primarily of rocky cliffs and headlands with small pocket beaches of sand or cobbles.

Skindiving and spearfishing for halibut are practiced all along the peninsula's offshore waters, especially at Torrance County Beach and Royal Palms State Beach. Lobsters are also found off Torrance Beach.

Surf fishing is conducted from Torrance County Beach and Point Vicente County Park. Barred surf perch is the major species caught. There is good surf fishing between Abalone Cove and

Portuguese Bend, but access to the shore is limited. Rockfishing is done from Torrance County Beach south to Point Vicente, although there is also limited access to the shore in this area. Royal Palms State Beach is another good rockfishing site.

Long Beach - San Pedro Bay Area

This area includes the coast and offshore waters between Point Fermin on the north and the Los Angeles-Orange County boundary on the south. This entire segment is owned by local government and consists of a sandy shoreline backed by urban developments.

Pier fishing is done at Belmont Pier and Cabrillo Pier; jetty fishing is found on the jetties protecting the outer harbor. The species caught here are much the same as those caught from piers and jetties in the Santa Monica Bay area.

Partyboats operate out of the ports of Long Beach and San Pedro from Belmont Pier. Skiffs can be rented or launched from Long Beach Harbor and Alamitos Bay, and live bait may be purchased from receivers anchored in the outer harbor. The catches from the partyboats and skiffs are basically the same as those in the Santa Monica Bay area.

Grunion runs occur on Cabrillo Beach, Belmont Shore, and off Bluff County Park at various times each year. The small silvery fish come up onto the sandy beaches to spawn and provide great sport for those trying to capture them since grunion may only be taken by hand. Predictions as to the times of the different runs may be obtained from the Department of Fish and Game.

Santa Barbara Island

Santa Barbara Island is located approximately 34 miles south-southwest of the Ventura-Los Angeles County boundary. The island is similar to Anacapa in that it too has towering seacliffs with few suitable landing areas. The remote location of this island and the lack of suitable harbor facilities limit the visits of small boats to the area.

Charter boats and private craft capable of open ocean cruising periodically visit the island to harvest abalone, spiny lobster, rock scallop, California sheephead, and a variety of other species. In 1970 the catch of fish and shellfish on charter boats per diver-hour was 0.53.

Santa Catalina Island

Santa Catalina Island lies approximately 18 miles southwest of Los Angeles Harbor. The island is a world-famous resort and is

2) The overburden is composed of unconsolidated sediments.

3) Reservoir beds have gentle dips at the structure crest.

4) Tension faulting common, graben blocks formed.

5) Miocene and younger ages.

6) Subsidence is associated with the oil field development by location and by time of occurrence.

Subsiding water producing areas have these additional common features:

1) Shallow, flat-lying aquifers covering large areas.

2) Subsidence rate is cyclic and controlled partially by seasonal fluid level fluctuations.

3) Pliocene and younger ages.

While none of the listed items were regarded as mandatory, a preponderance of them was considered to indicate subsidence susceptibility. Even in the presence of many of these factors, subsidence fails to occur most likely because of the supportive ability of the overlying strata. These overlying strata, particularly when in compression, may exert considerable resistance to bending or fracture.

In the case of oil fields, magnitudes of subsidence may be comparable to those found in circumstances of groundwater withdrawal. The greatest documented subsidence in the world has occurred at Wilmington oil field where a maximum of 8.8 m (29 ft.) of subsidence was reported to 1966, when subsidence was halted at Wilmington by repressurization in conjunction with the secondary recovery of oil. Subsidence, in an area 54 kilometers (40 miles) west of Fresno along the west sides of San Joaquin Valley, may soon exceed the Wilmington area record. In this area of the San Joaquin Valley, subsidence due to ground water withdrawal was recorded to have reached a maximum of 8.5 meter (28 ft.) by 1969.

a popular cruising ground for pleasure craft. The island is privately owned, but landing permits allow public use of the shoreline. The shoreline is predominantly rocky with numerous pocket beaches. Avalon and Isthmus Cove are the principal ports. A boat access campground is located at Isthmus Cove.

Skindivers, taking charter boats to the island harvest abalone, kelp bass, California sheephead, spiny lobster, rock scallop, and other species. Most of the divers taking charter boats favor Santa Catalina Island over all other islands, even though the catch/diver-hour is lower. Novice divers frequently pick this area as a training ground.

Catalina Island is also popular for partyboat fishing and is fished regularly during the summer months. Species taken include calico bass, barracuda, yellowtail, white seabass, and many others.

San Clemente Island

San Clemente Island is about 59 miles northwest of San Diego Bay and 18 miles southwest of Santa Catalina Island. The island is a United States Naval Reservation and is closed to the public. All vessels are warned that navigation in the vicinity of the island is dangerous because of gunfire and bombing. The coastline consists of rocky cliffs and a few pocket beaches.

Partyboat fishermen and skindivers taking charter boats to San Clemente harvest the same species taken at Catalina Island. In 1970, the catch per diver-hour was 0.44.

Major Sport Species

Surf perch
Bonito
Lobster
Yellowtail
Rockfish
Barracuda
Mackerel
White seabass
Kelp and sand bass
Albacore
California halibut
Sculpin

Freshwater Angler Use

There are no significant inland fisheries in Los Angeles County.

Orange County

Major Sport Areas: Sunset Bay, Huntington Beach, Newport Bay Harbor, Dana Point, and Ocean Beaches and Rocky Shores

Sunset Bay

This area includes the coastline and offshore waters bounded on the north by Seal Beach and on the south by Bolsa Chica State

Beach. This stretch of coast is comprised entirely of sandy beaches interrupted only by harbor entrances and river mouth jetties. Most of this shoreline is owned by local government and is available for public recreation. The only exception is the federally-owned entrance to Anaheim Bay.

Partyboats operate from the Seal Beach Pier and there is a fair-sized sport fish bait fishery in the Seal Beach and Anaheim Bay areas. Partyboat catches include rockfish, kelp and sand bass, Pacific bonito, lingcod, albacore, yellowtail and barracuda.

Pier fishing is enjoyed at the Seal Beach pier and jetties located at the entrances to Anaheim Bay, a deep military harbor, and Sunset Bay, a small craft harbor. Queenfish, white croaker, surf perch, Pacific bonito, California barracuda, top smelt and jack smelt are the most prevalent species taken from the local piers and jetties.

Public beaches along this stretch of the coast include Seal, Surfside, Sunset, and Bolsa Chica. Excellent surf fishing for corbina and croaker is found along the beaches from Sunset Beach to Bolsa Chica State Beach.

Huntington Beach

This area includes Huntington State Beach, Huntington Harbor, and the coastline and offshore waters. All of the shoreline, except for a short section immediately upcoast of Huntington Beach Pier, is owned by local government and is available for public use.

Partyboats operate from Huntington Beach Pier and Huntington Harbor. Partyboat catches include rockfish, Pacific bonito, yellowtail, albacore, kelp bass, sand bass, lingcod, and California barracuda. A sport fish bait fishery is conducted at Huntington Harbor. Skiff fishermen, limited by boat size and live bait capacity, still land substantial numbers of lingcod, rockfish, California barracuda, Pacific bonito, kelp bass and sand bass from the offshore waters.

Pier fishing, surf fishing, and Pismo clam digging are also available at Huntington State Beach.

Newport Bay Harbor

This area includes Newport Bay Harbor, Newport Beach, Balboa Beach and the offshore waters. This area is also comprised entirely of sandy beaches except for the opening at Newport Bay Harbor and the entire area is available for public use and recreation.

Partyboats operate out of Newport Bay Harbor, Newport Beach and Balboa Beach piers, and fish the offshore waters at different places along the coast. The main species landed by partyboat anglers include rockfish, kelp bass, sand bass, Pacific mackerel, halfmoon, sculpin, bonito, lingcod, yellowtail, albacore in season and California barracuda.

Skiff rentals and boat launching ramps are also found in the harbor area. Skiff fishermen catch spotfin and yellowfin croakers, perch, California halibut, and jacksmelt. Sportsmen also fish from the jetties at the mouth of the harbor and dig for clams and bait on the flats inside the harbor. Piers are located inside the harbor, and in the ocean at Newport Beach and at Balboa Beach. The main species of fish landed from the piers and jetties are shiner perch, black perch, topsmelt and jacksmelt. Sportsmen frequenting Newport Beach and Balboa Beach also partake of surf fishing and Pismo clam diving.

Dana Point Area

This area includes the coast and offshore waters bounded on the north by Dana Point and bounded on the south by the southernmost end of Dana Cove. Access is readily available to the entire area and many sportsmen take advantage of the recreational opportunities offered.

Facilities in Dana Cove include a jetty for jetty fishing and a small boat harbor where skiffs may be rented or launched.

Skin divers and SCUBA-divers have found that the waters off Dana Point provide excellent abalone diving.

Ocean Beaches and Rocky Shores

The remaining county shoreline includes the stretches of coast from Corona Del Mar to Dana Point and from Doheny State Beach to San Mateo Point.

From Corona Del Mar to Dana Point the coastline is rocky with numerous small pocket beaches. Over two-thirds of this coastline is privately owned with the remainder under the jurisdiction of city and county governments. Lobster diving, skindiving, spear fishing, abalone diving, clam diving, rock fishing and surf fishing are all enjoyed along this stretch of the coast.

The coastline from Doheny State Beach to San Mateo Point consists primarily of sandy beaches backed by tall cliffs. Over two-thirds of this stretch is publicly owned and used for recreation. This stretch includes Doheny and San Clemente State Beaches. Doheny Beach contains littleneck clam beds in cobble areas and sportsmen dig for the clams throughout the year. The coast between Doheny State Beach and San Clemente State Beach offers only limited surf fishing, but pier fishing, partyboat fishing, and surf fishing are all available.

Kelp beds are located off San Mateo Point and skiff fishermen frequenting these waters land catches of white sea bass, kelp bass, and California barracuda.

Major Sport Species

Surfperch
Bonito
Mackerel
White seabass
Kelp and sand bass
Barracuda
California halibut
Rockfish
Albacore
Yellowtail

Freshwater Angler Use

There are no significant inland fisheries in the Orange County coastal zone.

Wetlands of Orange County Possessing Wildlife Habitats of Critical Importance

Area	Type of Habitat in Acres
Anaheim Bay	Marsh, 480; mudflat, 40; water, 370[1]
Bolsa Bay	(approx. 1,500 acres of degraded wetlands with potential for improvement.)
Upper Newport Bay	Marsh, 200; mudflat, 650; water, 500

Type	Total Acres	Percent
Marsh	680	30
Mudflat	690	31
Water	870	39
	2,240[2]	

The salt marshes, mudflats and protected waters of Anaheim Bay, Bolsa Bay and Upper Newport Bay are critical to the maintenance of shorebird and waterfowl populations in the county, the state and to the Pacific Flyway. These three areas contain almost all of the remaining wetland acreage in the county.

[1] Including harbor and tidal channels.

[2] Bolsa Bay not included in calculating total acres of wetlands.
Lower Newport Bay and Huntington Harbor are also excluded as these areas contain little or no marsh or mudflat habitat.

San Diego County

Major Sport Areas: Oceanside, Mission Bay, San Diego, and Ocean Beaches and Rocky Shores

Oceanside

The City of Oceanside, lying just south of the Santa Margarita River mouth, has an excellent small craft harbor. The harbor has boat launching facilities and supports regularly scheduled deep sea party boats and charter boats. Boats from Oceanside fish along the kelp beds to the north of the harbor for yellowtail, barracuda, white sea bass, and kelp bass. During the summer months boats may also range offshore for albacore, bluefin tuna, and marlin.

Local fishermen also catch a wide variety of fish off the jetty at the mouth of the harbor and off the city pier. Some of the species commonly taken in this fishery include kelp and sand bass, perch, croakers, corvina, bonito, smelt, and California halibut.

Mission Bay

The bay has been dredged and made into a water-oriented recreation area. Fishing facilities provided in the area are boat launching ramps, partyboats, charter boats, and rental skiffs. Considerable fishing area is also provided by the harbor jetties, groins, and piers.

Harbor dredging allows for a good tidal interchange and a wide variety of fish and shellfish are found throughout the bay. The sheltered waters of the bay are ideal for skiff fishing and provide refuge for small craft fishing the offshore area. The species of fish taken in Mission Bay include those also taken in the Oceanside area.

San Diego

San Diego harbor supports one of the largest partyboat fleets in California. This fleet includes half-day and all-day partyboats, charter boats, and long range partyboats that fish in Mexican waters. A good percentage of the all-day partyboat fishing also takes place in Mexican waters off the Los Coronados Islands, a short distance south of the border. Other popular areas reached by this fleet are the La Jolla kelp beds and San Clemente Island.

The yellowtail is the most popular fish taken in the San Diego offshore area and, along with white seabass, barracuda, and albacore, is the most sought after species. The jetties, piers and bay waters themselves provide a variety of fishing opportunities for both shore anglers and small boat fishermen. Kelp and sand bass, halibut, perch and smelt are the usual fare with barracuda, white seabass, and bonito providing additional excitement periodically.

Ocean Beaches and Rocky Shores

The ocean beaches of San Diego County provide a variety of sport fishing opportunities. Popular activities include surf fishing, rock fishing, skin diving, clam digging, and grunion fishing.

Surf fishing is conducted along the county's sandy beaches wherever access is available. Popular surf fishing areas are the beaches at Camp Pendleton (by permit only), between Oceanside Marina and Torrey Pines State Park, False Point to Sunset Cliffs, Silver Strand State Park, and from Imperial Beach to the mouth of the Tijuana River. Grunion runs may occur on any sandy beach along the open coast, but runs are known to occur at Del Mar, La Jolla, Mission Beach, and the Coronado Strand. Surf perch, corbina, and croakers are the most sought after species along the sandy beach areas.

Popular rock fishing areas are the jetties at Oceanside, Mission Beach, San Diego Harbor, Point La Jolla to False Point, and near the lighthouse on the west side of Point Loma. Skin and SCUBA diving is popular in rocky areas and also offshore along the kelp beds. The most popular species taken are kelp bass, perch, sheephead, abalone, and lobsters.

Clam digging for littleneck clams is popular along the cobblestone beaches extending south from San Mateo Point to San Onofre. This area is also popular for capturing small octopus.

Major Sport Species

Abalone
Rockfish
Albacore
Yellowtail
Surf perch
Bonito
Mackerel
White seabass
Kelp and sand bass
Barracuda
California halibut
Lobster

Freshwater Angler Use

Buena Vista Lagoon contains warm water game fishes. The annual use is on the order of 1,000 angler days.

5. Commercial Biological Resources

d. Fishing Gear

Hester (1974) summarized the important commercial fishing gear and regulations.

Purse Seines and Roundhaul Nets

By far the major volume and value of fishes are taken with purse seines. Purse seines are nets for taking surface schooling fish. In operation the school is surrounded by a vertical wall of net supported at the surface by plastic-foam floats and weighted at the bottom by leads or chain. The bottom of the net is equipped with rings through which runs a purse line. By means of the purse line the bottom of the net can be closed and the fish school is trapped. The net is then "dried up", that is retrieved aboard by mechanical means until the fish are concentrated in a small area from which they can be scooped or pumped aboard.

Purse seines are of three sorts: tuna nets used by the high seas boats, mackerel nets and anchovy nets. Tuna nets are large, typically 600 fathoms long and 60 fathoms deep. Webbing is heavy nylon 4 1/2 inch to 7 1/2 inch mesh. The cost of nylon is rising and a new net is currently worth $125,000.

Mackerel nets are smaller and shallower. Typically 265 x 30 fathoms of light 1 1/2 to 2 inch web. A mackerel net is worth $60,000.

Anchovy nets are small mesh, usually 9/16 inch mesh with approximately the same overall dimensions as a mackerel net. Cost is higher owing to the greater weight of nylon in the net.

Purse seines are used in both deep and shallow water. For use in the latter, the nets are made to fish shallower by removing some of the webbing, or the depth is decreased by the use of "suspenders," ropes strung from the float line to the lead line. The San Pedro wetfish and tuna seiners in particular are adept at fishing shoal spots. On occasion the nets "hang up" on the bottom in these areas.

Bait fishermen and squid fishermen use a simpler net, the lampara, which was the forerunner to the purse seine. These nets lack rings and purse lines and are used in shallower water, They cost about $20,000.

Trawls

Trawls are used for taking midwater and bottom fish and shrimp. The single boat otter trawl, a sack net spread open by doors (otter boards) and towed along the bottom or in midwater at the end of wire cables, is the most common type trawl in use. The cost of trawl and doors is about $7,500. Trawlers operate north of San Francisco for the most part, and are rare south of Santa Barbara. This is owing to sportsmen's efforts to prohibit trawling in Southern California. Although the old restrictions prohibiting possession of trawl nets south of Santa Barbara county are no longer in force, most of this type of fishing is done to the north. According to Orcutt (1969) and Oliphant (personal communication, 1974) trawling occurs from around Point Mugu northward.

Set Lines and Long Lines

This gear consists of a long main-line with numerous short branch lines and baited hooks. The gear may be free floating, long lining for tuna and billfish, or anchored (set) on the bottom for shark, rockfish and halibut. Set lining is uncommon today. Long lining is common with Japanese and Taiwanese boats fishing offshore from Baja south. Unit cost of this gear is cheap, but a Japanese boat may carry 50 miles of line with 2,200 hooks worth $20-30,000.

Gill Nets

Gill, set and trammel nets are vertical walls of light, large mesh designed to catch fish by entangling. These nets may be allowed to drift near or at the surface, but this practice is rare south of Oregon. The common practice is to anchor the nets to the bottom in kelp beds or near points to intercept moving fish. This is the most productive way of taking fish such as barracuda, white sea bass, and halibut for the fresh fish market.

Pole and Line (Live Bait)

This type of fishing involves "chumming" the fish with live bait, usually anchovy, and catching the excited fish with artificial lures or baited hooks.

Hand Lines and Pole and Line for Rockfish

During the winter when surface gamefish are scarce off California and at all seasons by commercial boats, rockfish are taken using deep hand lines or lines and powered reels. Fishing is to depths of 200 fathoms on reefs and offshore banks.

Trolling

A method for taking larger predators such as tuna, principally albacore, billfish, and salmon. Commercial boats are usually small with one or two men aboard, and may troll 10 to 15 lines with artificial lures or baits. Sport boats usually use fewer lines, with rods and reels.

Traps

Lobster, crab and prawns are taken with wood, plastic or wire traps or with ring nets. Fishing is done in shallow (less than 50 fathoms) water. Traps may be buoyed separately or run in strings with up to 10 traps on a single buoyline.

Miscellaneous

Scoops: Formerly common, scooping or dipnetting is now rare except for flying fish, squid attracted to lights and surf smelt. This is a low-cost, low-prestige operation.

Spears and Harpoons: Used and legal for sharks, rays and swordfish and for game fish by submerged sport divers.

Diving: Commercial divers with wet suits and fins, some still use hard hat gear, take abalone and sea urchins from San Francisco to Magdalena Bay. This is a small boat operation, using usually one or two divers from an anchored boat. Numerous sportdivers take abalone, crab, lobster and fish.

Shovels and Rakes: For taking some species of clams commercially and by sportsmen for clams and cockles. An intertidal operation.

Table G5-1

WEIGHT (LBS), VALUE ($), AND PRINCIPAL MONTHS OF COMMERCIAL LANDINGS OF FISH AND SHELLFISH INTO THE THREE MAIN SOUTHERN CALIFORNIA REGIONS, 1968 THROUGH 1972[1]. (SANTA BARBARA AREA 1971 AND 1972) RANKED BY WEIGHT). (HORN, 1974)

Species	Los Angeles 1968[3] Lbs.	$	Month (s) of Largest Landings[2]
Yellowfin Tuna	112,123,459	17,444,740	3,4,5
Jack Mackerel	50,455,700	1,922,327	10,11,12
Skipjack	45,176,235	5,912,085	12,6,7,10
Anchovy	18,514,929	167,591	11,12,10
Pacific Bonito	14,609,914	606,880	8,9,1
Bluefin Tuna	10,050,936	1,528,647	9,7,8
Squid	7,693,532	117,389	1,2
Albacore	5,703,788	1,212,505	10,9
Pacific Mackerel	3,128,449	167,271	11,12,10
Abalone	1,563,540	372,314	4 to 12
White Croaker	706,583	42,772	3
White Seabass	703,399	205,352	8,9,7
Rockfish	656,547	95,794	1,3,12,2
Rock Crab	234,585	29,777	7,8,1
Grouper	207,632	47,812	1,2,11,12
Pacific Pompano	195,439	32,109	7,5,3,6
Blacksmith	137,634	4,124	5
Giant Sea Bass	136,648	24,821	2,8,9
Smelt	133,470	5,881	8,7
California Yellowtail	132,752	15,090	11,12,10
California Halibut	130,680	38,903	2,3,4
Swordfish	116,948	79,223	8,7,9
Spiny Lobster	108,805	104,435	10,1
Sardine	100,821	10,529	5
California Barracuda	97,119	23,013	6
Shark	86,107	11,113	5
Flyingfish	73,080	10,492	6,5
Perch	41,277	9,000	8,3,1,4
Bigeye Tuna	31,109	4,859	8
Halfmoon	19,422	4,481	10,9,8,11
Opaleye	10,798	2,103	10
Sculpin	7,684	2,737	5,6,8
Wahoo	6,190	1,426	2,6
California Sheephead	4,946	443	3,5
Misc. Sole	746	91	8
Ocean Whitefish	696	58	1
Sablefish	617	49	2,1
Lingcod	595	105	12,1

Table G5-1 (cont'd)

Species	Lbs	$	Months
Misc. Fish	255	49	6,10
English Sole	245	24	11
Petrale Sole	166	25	7
Octopus	151	49	1
Sanddab	148	28	6,5,7
Flounder	85	12	7
Skate	69	7	6
Salmon	35	19	9,8,4
TOTALS	273,103,965 lbs.	$30,258,554	
Excluding Skipjack & Yellowfin Tuna	115,804,271 lbs.	6,901,729	
	San Diego 1968[3]		
Yellowfin Tuna	40,903,050	6,368,029	5,4,7,3
Skipjack	14,058,052	1,858,288	11,6,12,10
Bluefin Tuna	2,885,339	427,186	8,7,9
Albacore	1,416,272	284,341	10
Abalone	740,973	174,763	6,1,9,10
Rockfish	286,944	41,462	5,1,3,2
Shark	130,720	6,923	7,8
Sculpin	117,304	31,863	7,6,8
White Seabass	99,416	32,617	12,3,2,9
Spiny Lobster	91,406	92,605	10,11
Bigeye Tuna	78,449	12,407	12,9
Pacific Bonito	46,710	1,989	8,7,6
Swordfish	44,868	29,963	8,9
California Halibut	38,763	12,685	1,3,2
California Barracuda	33,995	6,049	12,6,7,9
California Yellowtail	30,418	3,000	8,9,11
Halfmoon	30,195	6,053	6,5,8,7
Grouper	23,281	5,583	12,1
Giant Sea Bass	20,729	3,713	12,1
Perch	10,151	1,949	5,6,7
White Croaker	8,415	867	1,12,2
Rock Crab	7,032	429	10
California Sheephead	6,923	731	6
Pacific Mackerel	4,997	486	6
Misc. Sole	2,028	518	5,7,1,4
Sardine	2,007	451	10
Ocean Whitefish	1,856	148	8,1
Smelt	575	65	12,11
Flyingfish	511	121	7
Squid	505	15	6

Table G5-1 (cont'd)

Species	Lbs.	$	Months
Lingcod	427	37	12,2,1
Opaleye	375	61	12,7
Wahoo	120	18	6
Misc. Fish	98	16	10,8
Jack Mackerel	80	8	11
Sanddab	78	20	3
Cabezon	61	9	2,1
Petrale Sole	20	5	5
Octopus	12	3	1
TOTAL	61,123,158 Lbs.	$9,415,653	
Excluding Skipjack & Yellowfin Tuna	6,162,056	$1,189,336	
Los Angeles 1969[4]			
Yellowfin Tuna	160,198,363	25,848,825	4,5,2,3
Anchovy	109,777,744	1,072,059	12,10,11
Jack Mackerel	48,668,462	1,842,725	1 to 10
Skipjack	34,241,547	4,566,643	4,7
Pacific Bonito	14,489,968	676,676	7,8,1
Bluefin Tuna	11,176,168	1,784,220	7,9,8
Squid	6,182,983	124,206	12,11,1,2
Albacore	5,818,135	1,308,537	10,11
Pacific Mackerel	2,339,262	120,894	6,5,8,9
Abalone	1,279,224	415,426	1,4 to 8
White Seabass	839,406	265,641	3,4
Rockfish	624,293	109,606	4,5,6,1
Swordfish	624,064	318,794	9,8,10
White Croaker	376,447	31,421	12,3,2,1
Rock Crab	300,893	37,607	8,7,9
Blacksmith	246,517	6,259	6
California Yellowtail	199,815	24,777	2,9,1,10
Bigeye Tuna	193,788	30,929	3,2
Grouper	188,864	45,805	8,12,10
Pacific Pompano	169,055	30,151	3,4
Smelt	159,821	6,508	10,11
Spiny Lobster	127,320	144,522	10,12,11
Giant Sea Bass	126,215	24,061	2,10,9
Flyingfish	99,758	14,972	5,7,6
Sardine	82,843	9,218	6,7,5
Shark	73,087	9,669	8,10,9
California Halibut	71,112	24,834	3,2
California Barracuda	54,956	12,590	5,6
Perch	21,705	5,105	3,4

Table G5-1 (cont'd)

Species	Lbs		Months
Halfmoon	14,467	3,429	10,12,11
Opaleye	11,086	2,272	4,8,12
Sculpin	10,074	3,650	6
California Sheephead	5,123	500	7,5,6
Spotted Cabrilla	3,898	702	8
Ocean Whitefish	3,230	407	3,2
Sanddab	512	102	9,8
Sablefish	230	69	3
Miscellaneous Sole	213	36	8,11,2,10
Lingcod	91	14	1
Miscellaneous Fish	62	9	10
Salmon	23	20	8,10
Octopus	2	1	10
TOTALS	398,800,803 Lbs	$38,923,891	
Excluding Skipjack & Yellowfin Tuna	204,360,893 Lbs	$ 8,508,423	

San Diego 1969[4]

Species	Lbs		Months
Yellowfin Tuna	43,963,574	7,107,737	2,4,5,3
Skipjack	11,672,863	1,592,890	11,10,8
Bluefin Tuna	4,058,562	620,858	8,9,6
Pacific Bonito	1,740,015	86,353	8
Albacore	1,416,058	318,254	10,9,8
Abalone	514,768	148,527	6,7,11
Rockfish	221,923	35,166	4,3,2,1
Swordfish	204,755	95,034	10,9,8
White Seabass	181,856	59,101	3,10,5,1
Shark	163,564	24,540	7,8,12
Sculpin	104,789	29,476	1,8,11
Spiny Lobster	82,897	99,811	10,11,12
Grouper	66,247	16,562	2,12
California Halibut	37,138	12,678	7,8,11
Bigeye Tuna	35,831	5,659	1
California Yellowtail	34,340	3,710	11,1,10
Giant Sea Bass	27,469	5,465	3,5,11
Perch	22,959	3,912	8,7,4
Sardine	22,430	4,817	3,12,11
California Barracuda	19,627	4,287	5,6,4
Halfmoon	12,561	2,689	8,4,1
Pacific Mackerel	11,132	933	3,6,4
Anchovy	8,565	825	4,3
California Sheephead	7,768	903	7

Table G5-1 (cont'd)

Species	Lbs	$	Months
Opaleye	4,839	1,045	5
White Croaker	2,813	339	9,1
Rock Crab	2,156	164	2,1,3
Spotted Cabrilla	1,857	371	7
Ocean Whitefish	1,260	111	8,7
Miscellaneous Sole	892	237	3,4,9
Sablefish	823	159	12
Lingcod	330	33	1,2
Pacific Pompano	168	36	2
Miscellaneous Fish	62	13	4,5
Smelt	50	6	1
Squid	19	4	5
TOTALS	64,646,960Lbs	$10,282,705	
Excluding Skipjack & Yellowfin Tuna	9,010,523Lbs	$ 1,582,078	
	Los Angeles 1970		
Yellowfin Tuna	188,682,403	34,150,388	3,2,5,4
Anchovy	170,745,594	1,877,424	10,11,12,1
Skipjack	55,982,620	8,793,770	10,5,6
Jack Mackerel	43,846,149	1,728,106	10,9,5
Squid	11,085,253	249,584	12,1,2,11
Pacific Bonito	8,178,275	584,008	8,9,12
Bluefin Tuna	6,418,355	1,200,022	7,8
Albacore	5,693,816	1,568,385	10,8
Blacksmith	1,184,106	39,830	8,6,9
Abalone	1,015,920	331,060	11,5,12
White Seabass	820,054	286,889	8,4,3,2
Swordfish	667,815	384,458	7,8,10
Pacific Mackerel	618,038	49,090	7,5,6
Rockfish	414,808	81,530	3,2
White Croaker	351,760	32,283	1,12,11
Rock Crab	317,476	41,574	
Sardine	267,924	57,705	7,6
California Yellowtail	143,265	20,329	2,12
Pacific Pompano	117,637	36,018	12,9,10,11
Shark	104,207	14,849	6,1,5
Giant Sea Bass	98,064	22,223	3,2,1
Perch	88,364	4,424	8,6,3
Spiny Lobster	79,622	93,471	11,10,12,2
Smelt	77,915	4,062	10,11
Flyingfish	76,366	11,262	5,6,7
Halibut	70,798	27,934	6,5,7,4

Table G5-1 (cont'd)

Species	Lbs	$	Months
Opaleye	20,355	3,132	9,8,10
Bigeye Tuna	18,460	3,407	7
California Barracuda	17,013	4,737	3,5,6,4
Salema	16,450	493	7
Halfmoon	14,771	3,170	8,10,3,9
Pacific Saury	8,000	400	4
Grouper	5,570	1,393	1
Sculpin	1,664	668	3,2,1,4
California Sheephead	1,227	118	3,8,5,7
Lingcod	657	113	11,7,12
Ocean Whitefish	586	51	12,6,10
Sargo	548	99	6
Sanddab	450	102	11,3,9
Misc. Sole	244	37	8,11
Carp	185	-	12,11
Misc. Fish	170	55	1,8,9
Cabezon	165	16	2
Salmon	164	114	8,9
English	64	12	8,11
Octopus	37	13	2
Skate	35	3	4
TOTALS	497,253,417 Lbs.	$51,708,811	
Excluding Skipjack & Yellowfin Tuna	252,588,394 Lbs.	$ 8,764,653	
San Diego 1970[5]			
Yellowfin Tuna	43,274,235	7,736,816	2,3,4,5
Skipjack	20,496,509	3,289,329	10,5
Albacore	3,147,577	840,624	8,10,9,11
Bluefin Tuna	2,236,921	395,762	7,8
Abalone	479,093	133,836	7,9,12
Pacific Bonito	302,291	21,677	7,8,12,6
Rockfish	252,218	48,926	5,4,3,2
White Seabass	218,077	75,639	8,9,12,6
Sardine	174,395	43,596	4,3,9,8
Swordfish	153,812	84,833	11,10,7,8
Sculpin	153,297	45,770	7,6,8
Shark	133,941	21,891	7,6,8,12
Spiny Lobster	59,857	69,924	10,11,12
California Yellowtail	40,888	4,459	9,8,10
Giant Sea Bass	30,799	7,360	2,6,5,3
Halfmoon	23,838	5,331	5,6,7
California Halibut	17,003	6,978	2,3

Table G5-1 (cont'd)

Species	Lbs	$	Months
Rockcrab	11,476	1,078	2,11,12
Perch	10,749	1,847	6,5,7
California Barracuda	7,003	2,023	6,5
White Croaker	4,821	540	11,2,3
Pacific Mackerel	3,084	424	6,5,7
Flyingfish	2,265	367	7
Opaleye	2,097	401	5,7,6,1
California Sheephead	2,080	261	11,4,5,6
Grouper	1,572	393	2
Blacksmith	1,413	181	6,7
Ocean Whitefish	1,192	183	3,6,10
Sablefish	1,041	111	11,8
Jack Mackerel	695	32	7,6
Wahoo	650	65	5
Lingcod	552	78	11,7,10
Misc. Sole	404	116	3,4
Misc. Fish	355	88	6,8
Squid	197	20	11,12
Flounder	167	26	8,7,6
Sanddab	138	69	6
English Sole	70	10	8
Octopus	55	11	10
Pacific Herring	10	1	12
TOTALS	71,246,637 Lbs	$12,841,076	
Excluding Skipjack & Yellowfin Tuna	7,475,893 Lbs	$1,814,931	

Los Angeles 1971[6]

Species	Lbs	$	Months
Yellowfin Tuna	122,445,911	25,517,727	2,4,3
Skipjack	78,015,296	14,339,212	6,7,5
Anchovy	67,255,374	759,986	1,10
Jack Mackerel	57,411,853	2,313,697	11,3
Pacific Bonito	17,111,661	1,558,873	9,8,10
Bluefin Tuna	10,379,116	2,263,945	6,10,8,7
Squid	8,185,108	150,605	1,2,5
Albacore	6,403,280	2,018,314	9,8,7,10
Bigeye Tuna	1,586,784	332,904	12
Abalone	887,464	247,503	1,3,5
Rockfish	451,216	92,709	11,3,1
White Seabass	421,451	163,987	3,4,12
Rock Crab	360,296	51,522	8,7,9,12
California Yellowtail	332,794	37,673	8,9
White Croaker	227,028	16,371	3,12,1
Pacific Pompano	175,798	40,679	3,4,1

Table G5-1 (cont'd)

Species	Lbs.	$	Months
Sardine	163,686	35,160	8,7,9
Flyingfish	160,266	23,976	6,7,8,5
Pacific Mackerel	153,531	7,230	12,11
Shark	120,939	16,980	6,7,5
Smelt	107,817	5,785	10,11,9
Giant Sea Bass	104,393	23,947	11,10,9
California Halibut	78,863	30,599	6,5
Spiny Lobster	73,553	103,445	11,10,12
Swordfish	53,542	27,033	9,10
Blacksmith	42,340	965	4,6
Petrale Sole	16,235	2,760	12
Perch	14,999	3,028	6
Halfmoon	10,526	2,623	6,5,8
California Barracuda	8,998	3,015	6,11
Carp	6,766	970	3,4
California Sheephead	6,070	667	7,6,2
Opaleye	3,217	672	8,6,5
Lingcod	3,157	362	12
English Sole	2,380	286	12
Sculpin	1,886	693	6,3
Ocean Whitefish	1,072	102	6,12,4
Sablefish	731	92	6,7,8
Dolphinfish	730	126	11
Sanddab	468	99	8
Sargo	287	66	6,4
Miscellaneous Sole	184	24	8
Miscellaneous Fish	133	35	6
Flounder	8	2	3
TOTAL	373,287,437 Lbs.	$50,196,438	
Excluding Skipjack & Yellowfin Tuna	172,826,230 Lbs.	$10,339,499	
	San Diego 1971[6]		
Yellowfin Tuna	28,495,200	5,924,152	3,2,4
Skipjack	23,362,342	4,289,326	6,4,3
Bluefin Tuna	6,371,850	1,274,370	8,7,6,9
Albacore	5,898,994	1,849,925	7,8
Pacific Bonito	2,515,189	232,152	9,8
Abalone	631,425	185,250	1,5,6,7
Rockfish	377,531	80,328	3,1,5,2
White Seabass	233,264	99,977	6,3,11
Bigeye Tuna	219,254	45,714	12,2,3
Shark	199,895	37,982	7,9,6,10

Table G5-1 (cont'd)

Species	Lbs.	$	Months
Sardine	134,200	33,550	4,5,3,7
Sculpin	129,258	41,402	7,6,8
Swordfish	72,627	43,853	8,9,10
Spiny Lobster	72,570	98,245	10,11,12
California Yellowtail	57,696	7,160	11,2,3
Rock Crab	20,319	2,869	2,1,3,12
Halfmoon	12,596	2,947	7,6,2
California Halibut	12,263	5,691	1,3,5
Giant Sea Bass	11,983	3,190	12,3,2
Perch	10,811	2,249	10,8,6
Jack Mackerel	10,307	544	8
California Barracuda	7,894	2,454	6
White Croaker	3,203	386	2,3,1
Ocean Whitefish	2,611	319	11
California Sheephead	2,374	352	11,6,3
Pacific Mackerel	2,245	328	6
Opaleye	2,064	282	2,4,12
Squid	1,945	200	3,2
Miscellaneous Sole	1,215	343	4,8
Lingcod	505	59	6
Sablefish	460	46	5
Miscellaneous Fish	335	98	6
Anchovy	327	54	2,3
Sanddab	171	46	7,8,6
Sargo	147	15	7
Dolphinfish	109	27	12
Flounder	46	12	6
Cabezon	32	4	2,3,11
Miscellaneous Crustacean	30	12	11
Pompano	13	3	3
Smelt	8	1	2
TOTALS	68,875,134 Lbs	$14,265,923	
Excluding Skipjack & Yellowfin Tuna	17,017,592 Lbs	$ 4,052,445	
Santa Barbara 1971[6,8]			
Anchovy	19,721,639	268,214	12,10,1,11
Squid	6,683,735	96,914	1,4,2
Albacore	3,700	1,495	9,8,10
Jack Mackerel	2,295,898	91,836	11,4,6
Rockfish	823,600	65,508	6,10,11,9
Abalone	1,097,570	396,611	1,7,6,12
Pacific Bonito	599,800	47,323	11,9
Misc. Animal Food	359,500	7,191	6,5

Table G5-1 (cont'd)

Species	Lbs.	$	Months
Petrale Sole	204,200	33,934	12,11,5
English Sole	297,200	28,700	2,1,3
Lingcod	66,175	3,596	11,10,9,12
White Seabass	120,200	46,186	10
Rock Crab	129,422	11,713	1,2,3
California Halibut	66,500	36,876	8,7,6,1
Salmon	4,778	3,534	6,7,5,9
Spiny Lobster	75,323	102,839	11,10,1,12
Rex Sole	36,027	4,122	2,1,10,11
Shark	37,750	4,831	5,12,11,6
Sand Sole	29,866	4,178	1,3
Swordfish	25,100	13,843	10,9
Dover Sole			5,6,9
Turbot	18,500		5,3,4
Pacific Hake			6
Flounder			3,2,4
Perch			1,2,3
Miscellaneous Sole			12,11
Market Crab			4,5,3
Ocean Shrimp			6
Cabezon			2,1,3
Pacific Pompano			5
Sanddab			6
Giant Sea Bass			8
Sablefish			1
California Sheephead			12,2
California Barracuda			9,11
White Croaker			5,4,1
Sea Urchin			6
Skate			3,5,6
Smelt			4
Pacific Mackerel			1
California Yellowtail			9,8
Miscellaneous Fish			11
Spot Prawn			6
Ocean Whitefish			8
Totals	32,696,483 Lbs.	$ 1,269,444	

Los Angeles 1972[7]

Species	Lbs.
Yellowfin Tuna	194,764,106
Anchovy	109,174,438
Jack Mackerel	50,216,821
Skipjack	24,294,775
Pacific Bonito	17,651,639
Bluefin Tuna	15,540,401
Albacore	4,768,680

Table G5-1 (cont'd)

Species	Lbs.	$	Months
Squid	4,256,100		
Black Skipjack	992,744		
Rockfish	669,237		
Rock Crab	625,627		
Abalone	624,088		
White Seabass	412,391		
Sardine	326,309		
White Croaker	249,499		
Bigeye Tuna	187,225		
Spiny Lobster	173,713		
California Yellowtail	172,903		
Pacific Pompano	146,975		
Flyingfish	128,889		
Perch	125,341		
Swordfish	122,559		
Smelt	119,801		
Pacific Mackerel	105,466		
Giant Sea Bass	87,131		
Blacksmith	75,880		
Shark	75,347		
California Halibut	40,244		
Opaleye	15,082		
California Barracuda	9,401		
Halfmoon	5,914		
Sculpin	5,195		
California Sheephead	5,042		
Dolphinfish	2,371		
English Sole	1,353		
Sablefish	1,206		
Lingcod	1,083		
Dover Sole	1,020		
Wahoo	893		
Sargo	866		
Ocean Whitefish	862		
Miscellaneous Sole	611		
Petrale Sole	563		
Skate	544		
Turbot	360		
Pacific Hake	360		
Sanddab	359		
Miscellaneous Fish	215		
Octopus	190		
Eel	61		
Rex Sole	49		

Table G5-1 (cont'd)

Species	Lbs	$	Months
Flounder	35		
Miscellaneous Mollusks	27		
Longjaw Mudsucker	2		
TOTAL	426,181,990 Lbs		
Excluding Skipjack & Yellowfin Tuna	207,123,109		
	San Diego 1972[7]		
Yellowfin Tuna	46,940,876		
Skipjack	11,650,109		
Bluefin Tuna	9,337,320		
Albacore	3,516,643		
Pacific Bonito	1,969,893		
Rockfish	621,802		
Abalone	495,941		
White Seabass	279,262		
Spiny Lobster	137,168		
Sculpin	126,821		
Black Skipjack	116,366		
Shark	115,988		
Swordfish	108,858		
California Yellowtail	84,901		
Sardine	45,921		
Rock Crab	25,552		
Perch	23,388		
California Halibut	23,189		
Halfmoon	21,208		
Giant Sea Bass	7,374		
Dolphinfish	5,074		
Sea Urchin	4,086		
California Barracuda	3,634		
Pacific Mackerel	2,612		
California Sheephead	1,878		
Ocean Whitefish	1,707		
White Croaker	1,566		
Anchovy	1,335		
Miscellaneous Sole	1,249		
Wahoo	914		
Petrale Sole	554		
Squid	499		
Carp	475		
Jack Mackerel	458		
Opaleye	308		
Sablefish	282		

Table G5-1 (cont'd)

Species	Lbs	$	Months
Sanddab	272		
Lingcod	257		
Flounder	235		
Smelt	199		
Miscellaneous Fish	144		
Giant Pacific Oyster	128		
Pacific Pompano	80		
Cabezon	58		
Eel	48		
Salmon	41		
Mullet	33		
Spotted Cabrilla	26		
Octopus	13		
TOTAL	75,680,976 Lbs		
Excluding Skipjack & Yellowfin Tuna	17,089,991 Lbs.		
	Santa Barbara 1972[7,9]		
Anchovy	27,476,975		
Albacore	14,974		
Squid	3,644,435		
Rockfish	1,162,774		
Pacific Bonito	2,600,907		
Abalone	1,630,135		
Jack Mackerel	770,600		
Petale Sole	107,725		
Lingcod	48,503		
Miscellaneous Animal Food	248,370		
English Sole	130,750		
Rock Crab	11,713		
Salmon	5,694		
Dover Sole	44,905		
California Halibut	34,270		
Spiny Lobster	86,702		
White Seabass	58,881		
Shark	51,308		
Rex Sole	51,994		
Sea Urchin	2,490		
Smelt	41,750		
Swordfish	34,320		
Sand Sole	40		
Perch	281		

Table G5-1 (cont'd)

Species	Lbs.	$	Months
Miscellaneous Sole			
Sablefish			
Flounder			
Turbot			
White Croaker			
Pacific Pompano			
Cabezon			
California Barracuda			
Pacific Hake			
Giant Sea Bass			
Octopus			
Sanddab			
Skate			
Dolphinfish			
California Yellowtail			
Miscellaneous Fish			
California Sheephead			
Total	38,260,496		

1 = Weight only for 1972
2 = Numbers represent consecutive months of year; months (as many as four) ranked according to weight of catch.
3 = From Heimann and Carlisle 1970
4 = From Pinkas 1970
5 = From Bell 1971
6 = From Oliphant and staff 1973
7 = From Bell 1974
8 = Omitting Ports North of Point Conception (Morro Bay & Avila)
9 = Omitting Ports North of Point Conception; Oliphant, 1974, personal files

Table G5-2 . Major Commercial Fishing Methods and Catch in Southern California (Oliphant, 1973, Frey, 1973, Oliphant, 1974, Personal communication)

Santa Barbara area	Major harvest method	Recent history of fishery (State wide)	Landings in million pounds (year 1969)	
Anchovy	Purse sein	Greatly increased	- 3 (1965)	-1135 (1969)
squid	Purse sein	Increased	- 2 (1960)	20 (1969)
Jack Mackerel	Purse sein	Decreased	100 (1961)	50 (1969)
Rockfish	Trawl & Hook and line	Decreasing since 1960, relatively stable since (1960).	13.5 (1960)	9 (1969)
Pacific bonito	Purse sein	Increased	4 (1965)	17 (1969)
Misc. (animal food)	Trawl	———	———	———
English sole	Trawl	Decreased	4.6 (1965)	3.7 (1969)
Petrale sole	Trawl	Relatively steady		2.7 (1969)
White seabass	Gill net	Decreased	1.3 (1965)	1.0 (1969)
California halibut	Trawl	Decreased	1.25 (1965)	0.25 (1969)
Turbot	Trawl	Decreased	———	———
Shark	Methods vary	Relatively steady		0.5 (1969)
Swordfish	Surface harpooning	Increased	0.3 (1965)	1.0 (1969
Albacore	Hook & line	Decreased	20 (1965)	12 (1969)

Continued - Table G5-2

Los Angeles Area	Major harvest method	Recent history of fishery (Statewide) Landings in million pounds (year 1969)
Anchovy	Purse sein	See Santa Barbara
Jack mackerel	Purse sein	See Santa Barbara
Pacific bonito	Purse sein	See Santa Barbara
Bluefin tuna	Purse sein	Fluctuates year to year, 15 (1969)
Squid	Purse sein	See Santa Barbara
albacore	Hook and line	Decreased, 20 (1965) 12 (1969)
Bigeye tuna	Purse sein; Hook and line	———
Rockfish	Hook and line	See Santa Barbara
White seabass	Gill nets	See Santa Barbara
California yellowtail	Purse sein	Constantly low, decreased in 1955
white crooker	Trawl	Decreased, 1.2 (1960) 0.5(1969)
perch	Hook & line or gill net	———
Swordfish	Surface harpooning	See Santa Barbara
Pacific mackerel	Purse sein	Decreased 45 (1962) 0.3(1969)
Shark	Methods vary	See Santa Barbara
California halibut	Trammel net or Long line	See Santa Barbara

Table G5-2 (continued)

San Diego Area	Major harvest method	Recent history of fishery (Statewide) Landings in million pounds ([illegible])
Bluefin tuna	Purse sein	See Los Angeles
Albacore	Purse sein	See Los Angeles
Pacific bonito	Purse sein	See Santa Barbara
Rockfish	Hook & Line	See Santa Barbara
White seabass	Gill nets	See Santa Barbara
Bigeye tuna	Purse sein	___
Shark	Methods vary	See Santa Barbara
Sculpin	___	Increasing, 0.02 (1960) 9.12 (1969)
Swordfish	Surface horpooning	See Santa Barbara
California Yellowtail	Purse sein	See Los Angeles
California halibut	Trammel net & long line	See Santa Barbara

TABLE G5-3

Recorded Catch of Live Bait for Saltwater Sportfishing 1968-1972

Species	Thousands of pounds*				
	1968	1969	1970	1971	1972
Anchovy	14,353	10,627	12,210	12,774	11,700
Mackerel, jack	158	103	---	9	5
Mackerel, Pacific	---	8	---	1	---
Sardine, adult	57	34	---	---	T
Sardine, juvenile	---	---	6	T	T
Squid	23	9	---	10	---
Miscellaneous †	57	---	4	---	16
Total pounds	14,648	10,781	12,220	12,794	11,721
Number of Vessels‡	19	10	11	14	12

* Weights are estimated from voluntary records. They should be regarded as minimal because some fishermen do not supply catch information.

T Less than 500 pounds.

† Consists primarily of queenfish and white croaker.

‡ The number of live bait fishing vessels for which landings were reported. These numbers differ slightly from those in previous catch bulletins, since the earlier landing records, as submitted sometimes included the catch of more than one boat.

Source: Oliphant personal files (1974)

TABLE G5-4

SHELLFISH

Shellfish Species	Geographic Range	Habitat	Peak Spawning or Setting Period	Relatively Abundant	Diet
Ghost Shrimp Callianassa californiensis	Alaska-Baja, Calif.	Sandy mud in marine bays & estuaries	Summer	+	Detritus in mud
Callianassa gigas	"	"	"	+	"
Blue Mud Shrimp Upogebia pugettensis	Alaska-Baja, Calif.	Open beaches with rocky boulder shore	Summer	+	"
Sand Crab Emerita analoga	British Columbia-Panama	Sandy beaches	Late Spring-Summer	+	Plankton and detritus in the surf
Ocean Shrimp Pandalus jordani	Aleutian Islands-San Diego	Shrimp beds in 150 to 1,200 ft. of water assoc. with green mud bottoms	Early Summer	-	Plankton
Bay Shrimp Crago franciscorum	Alaska-San Diego	Migrates within bays to depths of 180 ft.	Winter to Early Summer	-	Bottom detritus, bottom invertebrates, at least clams
Crago nigricauda	Alaska-Baja, Calif.	Migrates within bays to depths of 200 ft.	Spring & Summer	-	"
Crago nigromaculata	N. Calif-Baja, Calif.	Migrates within bays to depths of 200 ft.		-	"

TABLE G5-4 (cont'd)

Shellfish Species	Geographic Range	Habitat	Peak Spawning or Setting Period	Relatively Abundant	Diet
Spot Prawn *Pandalus platyceros*	Alaska-San Diego	Deep canyons 150 -1600 ft. deep on green mud bottoms	Winter & Spring	+	Bottom detritus, bottom invertebrates, disabled fishes
Ridgeback Prawn *Eusicyonia ingentis*	Pt. Conception-Baja, Calif.	Sandy bottoms off Ventura in 180 to 270 ft. of water	Not Known	+	Probably detritus
Market Crab *Cancer magister*	Alaska-Baja, Calif.	Sandy bottoms of bays	Early Summer (Setting)	-	Fish clams, smaller crustaceans-definite preference for fresh material
Rock Crabs Yellow Crab *Cancer anthonyi*	Eureka-Baja, Calif.	Inshore, variety of substrates, particularly rocky areas	Females carry eggs in winter	+	Predators of oysters, abalone, and other molluscs
Rock Crab *Cancer antennarius*	British Columbia-Baja, Calif.	"	"	+	"
Red Crab *Cancer productus*	"	"	"	+	"
California Spiny Lobster *Panulirus interruptus*	Monterey Bay-Baja, Calif.	Rocky regions from intertidal zone to 240 ft.	Complex life cycle extending over most of the year	+	Bottom invertebrates

TABLE G5-4 (cont'd)

Shellfish Species	Geographic Range	Habitat	Peak Spawning or Setting Period	Relatively Abundant	Diet
Pelagic Red Crab					
Galatheidae	California Current	Both in water (pelagic) or bottom dwellers in Calif. Current in regions of upwelling	Not given	+ +	Phytoplankton
Littleneck Clams					
Smooth Chione					
Chione fluctifraga	So. of Pt. Conception	Muddy back bays	Not known	+ Losing areas because of land fill	Not documented
Common Littleneck					
Protothaca staminea	Throughout Calif.	Outer coast on cobble patches and in bays & estuaries	Not Known	+	Not documented
Plus 4 others of lesser importance					
Pismo Clam					
Tivela stultorum	Halfmoon Bay-Baja, Calif.	Intertidal on flat sandy beaches exposed to full force of waves. Intertidal to a depth of 80 ft.	Summer & Fall	+	Filter feeder on plankton
Gaper Clam					
Tresus nuttalli	Puget Sound-Baja, Calif.	Sandy or sandy-mud bottoms in bays, estuaries, & more sheltered outer coast areas; intertidal to depth of 100 ft.	Spring to Fall	-	Filter feeder on plankton and probably detritus

TABLE G5-4 (cont'd)

Shellfish Species	Geographic Range	Habitat	Peak Spawning or Setting Period	Relatively Abundant	Diet
Washington Clam Saxidomus nuttalli	Humboldt Bay, - Baja, Calif.	Buried 12 to 18 in. in mud thru sand bottoms of bays, lagoons & estuaries	Spring to Fall	-	Filter feeder on plankton & probably detritus
Olympia Oyster Ostrea lurida	-	Attached to solid objects	-	-	"
Abalone **Red Abalone Haliotis rufescens	Oregon-Baja, Calif.	Intertidal to 180 ft. deep (most abundant 25-80 ft.) around rocky areas & especially kelp beds	Spring thru Fall	+	Benthic diatoms, coralline algae, bull kelp, giant kelp depending on age. (See text)
*Pink Abalone Haliotis corrugata	Pt. Conception-Baja, Calif.	Apparently Similar to the red abalone	Apparently Similar to the red abalone	+	"
*White Abalone Haliotis sorenseni	"	"	"	+	"
*Green Abalone Haliotis fulgens	"	"	"	+	"
Black Abalone Haliotis cracheroddi	Oregon-Baja, Calif.	Intertidal Areas		+	-
Flat Abalone Haliotis walallensis	British Columbia-LaJolla	-	-	- Rare	-

TABLE G5-4 (cont'd)

Shellfish Species	Geographic Range	Habitat	Peak Spawning or Setting Period	Relatively Abundant	Diet
Threaded Abalone *Haliotis assimilis*	Pt. Conception - Baja, Calif.	Apparently Similar to the red abalone	Apparently, the same as the red abalone	+	Similar to red abalone
Squid *Loligo opalescens*	British Columbia - Baja, Calif.	Swims within watermass (pelagic), but congregate in sandy semi-protected areas when spawning	Winter	+	Small fish, shrimp

TABLE G5-5 (from: Horn, 1974b)

Commercial Shellfisheries

Common Name	Commercial Range	Harvest Methods	Commercial Use	Statewide Annual Landings (lbs.) Dollar Value, (Year)	State of Fishery
Ghost Shrimps & Blue Mud Shrimp	Centered around San Diego	Shovel digging, hydraulic pumping, stamping on sandy beaches	Sportfish Bait	2,884-8,190 lbs. avg. 5,979 lbs (1963-1968) 7,748 lbs. $31,379 (1968)	New fishery; well under max. utilization, but many S. Calif. estuaries (it's habitat) being destroyed.
Sand Crabs	Most from 20 mi. of sandy beach in S. Calif.	Small wire-mesh net	Sportfish Bait	8,300 lbs. worth $17,152 (1967)	New fishery; well under max. utilization, fishery appears to be in good condition.
Spot Prawn	Largely off Monterey, little off S. Calif.	Crab traps or "longline"	-	Avg. 2,000 lbs. Avg. $1,500 to $2,000 (1961-71)	Largely undeveloped; large populations appear to be limited to Monterey & Catalina Canyons
Ridgeback Prawn	Santa Barbara to Ventura Areas	Bottom trawling nets, in connection w/other fishes	-	Max. 30,238 lbs. (1966) Avg. 400 lbs. (1967-68)	Young fishery not yet fully developed; outlook not bright because of law demand

TABLE G5-5 (cont'd)

Common Name	Commercial Range	Harvest Methods	Commercial Use	Statewide Annual Landings (lbs.) Dollar Value, (Year)	State of Fishery
Rock Crabs	Santa Barbara	-	New fishery, used to be largely a sport fishery - a pest which eats oysters & abalone	503,710 lbs. $65,210 (1971 S. Calif. only)	New fishery; well under max. utilization. Populations appear to be abundant in most areas.
California Spiny Lobster	Point Conception to Mexican Border (closed areas in Santa Monica Bay & Santa Catalina Island)	Box crab traps SCUBA - Sportsfishery	Human food-market demand high. Sportfishery	Avg. 775,000 lbs. (1955-65) 308,000 lbs. (1969) $300,000 (late 1960's)	Commercial for over 70 yrs; experiencing rapid decline in catch despite high consumer demand and prices of $1.25 per pound to fishermen
Pelagic Red Crab	California Current	Bottom Otter Trawl	None	-	Resource potential high. "Higher catch rates to 25 tons per hour have been suggested for demersal otter trawl fishing in upwelling areas & at depths that corresp. to the oxygen minimum".

TABLE G5-5 (cont'd)

Common Name	Commercial Range	Harvest Methods	Commercial Use	Statewide Annual Landings (lbs.) Dollar Value, (Year)	State of Fishery
Abalone	Statewide	Diving	Human Consumption	2,945,000 lbs. $953.000 (1971)	Old fishery, beginning before 1900; populations down, catch down over 1 million pounds from mid 1960's despite large effort, large demand, and high value.
Little Neck Clams	Species dependent	Digging	Sports fishery-Commercial fishing not economical because of method of harvesting	-	Good except for those species restricted to muddy back-bay environments.
Pismo Clam		Digging, Skin diving	Commercial fishing outlawed, sold as bait but is shipped in from Mexico Sport fishery	-	Many in deeper waters not utilized.

Table G5-6

COMMERCIAL SHELLFISH LANDING IN SOUTHERN CALIFORNIA 1971 AND 1972
(OLIPHANT AND STAFF, 1973, OLIPHANT, 1974, UNPUBLISHED FILES)

AREA	Landings (Lbs.)		Landing Value	
Santa Barbara	1971	1972	1971	1972
Abalone (total)	1,097,570	1,630,135	$396,611	$550,996
red abalone		644,034		$330,682
black abalone		844,990		$143,818
pink abalone		137,883		$ 76,272
green abalone		3,228		$ 1,505
white abalone				
Spiny lobster	75,323	86,702	$102,839	$131,480
Rock crab	129,422	122,272	$ 11,713	$ 13,021
Total	1,302,315	1,839,109	$511,163	$695,497
Los Angeles				
Abalone (total)	883,685	619,384	$246,419	$264,988
red abalone		19,745		$ 9,823
black abalone		130,008		$ 21,382
pink abalone		155,284		$ 76,217
green abalone		256,806		$124,412
white abalone		57,541		$ 33,154
Spiny lobster	73,553	172,837	$103,445	$271,910
Rock crab	360,165	623,231	$ 51,503	$ 91,524
Total	1,317,403	1,415,452	$401,367	$628,422
San Diego				
Abalone (total)	627,567	494,840	$184,232	$256,062
red abalone		107,103		$ 52,189
black abalone		32,269		$ 7,444
pink abalone		108,121		$ 56,037
green abalone		161,224		$ 87,909
white abalone		86,123		$ 52,483
Spiny lobster	72,112	137,196	$ 97,625	$217,621
Rock crab	14,123	19,053	$ 1,994	$ 3,007
Total	713,802	651,089	$283,851	$476,690
Total (all areas)	3,333,520	3,905,650	$1,196,381	$1,800,609

TABLE G5-7 Source: Oliphant, personal files (1974)

Inshore Bait Landings by Area

Pounds and Value

1972

Species	Sacramento	San Francisco and Monterey	Los Angeles	San Diego	Statewide*
Clam					
Freshwater	640,527	---	---	---	640,527
	$ 67,430	---	---	---	$ 67,430
Gaper	---	---	---	---	471
	---	---	---	---	$ 118
Jacknife	---	---	45,551	12,653	58,204
	---	---	$ 30,580	$ 7,612	$ 38,192
Purple	---	---	1,423	14,316	15,739
	---	---	$ 810	$ 6,919	$ 7,729
Unclassified	---	---	---	---	90
	---	---	---	---	$ 52
Crab					
Sand	---	---	6,786	28	6,814
	---	---	$ 20,770	$ 175	$ 20,945
Shore	---	---	25	---	26
	---	---	5	$ ---	$ 7
Crayfish	---	---	---	---	3,979
	---	---	---	---	$ 1,544
Killifish	---	---	---	---	11
	---	---	---	---	$ 32
Mudsucker, longjaw	---	---	---	223	6,511
	---	---	---	$ 88	$ 5,830
Mussel (bay and rock)	---	---	101,114	14,428	115,799
	---	---	$ 17,121	$ 2,024	$ 19,171
Sculpin, staghorn	702	185	---	---	887
	$ 2,297	$ 695	---	---	$ 2,992
Shrimp					
Bay	71,402	1,665	---	---	73,067
	$113,433	$ 2,423	---	---	$115,856
Brine	---	---	---	---	300,065
	---	---	---	---	$174,934
Ghost	---	---	15,672	5,882	21,554
	---	---	$ 35,718	$11,222	$ 46,940
Red	---	---	1,103	---	1,103
	---	---	$ 1,103	---	$ 1,103
TOTAL	712,631	1,850	171,674	47,530	1,244,847
	$183,160	$ 3,118	$106,107	$28,040	$502,375

*Some figures are reported statewide only to avoid revealing the business of an individual in an area.

Table G5-8

Conversion Factors For Inshore Bait

Crab, sand	0.041	pound per dozen
	4.5	pounds per gallon
Crab, shore	0.013	pound per dozen
Mudsucker	0.465	pound per dozen
Mussel	80.000	pounds per sack
Sculpin, staghorn	0.465	pound per dozen
Shrimp, ghost	0.082	pound per dozen

From: Oliphant (1973)

Table G5-9 Annual yields and values of kelp from California beds. Basic data from Department of Fish and Game. Dry weight was taken as 14% of the wet weight. (Source, North, 1971).

Year	Fresh weight, tons	Estimated dry weight, tons	Estimated landed value, dollars	Estimated market value, dollars
1913	2,500[1]	350	—	3,000[2]
1916	134,537	18,800	—	605,000
1917	394,974	55,300	—	2,370,000
1918	395,098	55,300	—	2,370,000
1919	16,673	2,330	—	28,000
1920	25,464	3,560	—	42,700
1931	260	36	—	—
1932	10,315	1,440	—	—
1933	21,621	3,030	—	—
1934	15,850	2,220	—	—
1935	30,602	4,290	—	—
1936	49,317	6,900	—	—
1937	43,953	6,150	—	—
1938	47,697	6,680	—	—
1939	56,736	7,940	—	—
1940	59,004	7,800	—	—
1941	55,717	7,790	—	1,500,000 (value of algin only)[3]
1942	61,898	8,670	—	—
1943	47,958	6,710	—	—
1944	53,030	7,420	—	—
1945	59,181	8,290	—	—
1946	91,069	12,700	—	—
1947	74,237	10,400	—	—
1948	78,641	11,000	—	—
1949	83,346	11,700	—	—
1950	100,602	14,100	1,260,000–1,750,000[4]	—
1951	114,760	16,100	1,450,000–2,010,000	—
1952	110,159	15,400	1,380,000–1,910,000	—
1953	126,649	17,700	1,590,000–2,220,000	—
1954	106,216	14,900	1,390,000–1,860,000	—
1955	124,063	17,400	1,570,000–2,170,000	—
1956	117,816	16,500	1,490,000–2,060,000	—
1957	94,207	13,200	1,190,000–1,650,000	—
1958	114,062	16,000	1,440,000–2,000,000	—
1959	89,599	12,500	1,130,000–1,560,000	—
1960	120,300	16,800	1,510,000–2,100,000	—
1961	129,256	18,100	1,630,000–2,260,000	—
1962	140,232	19,600	1,760,000–2,450,000	—
1963	121,031	16,900	1,530,000–1,910,000	—
1964	127,254	17,800	1,600,000–2,220,000	—
1965[5]	135,129	18,800	1,690,000–2,110,000	—

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[1] Estimate by Scofield (1959).

[2] Based on Burds (1915) estimate that the constituents of a dry ton of kelp were worth $12.00.

[3] Scheffer (1944); includes a small but unknown amount of algin from Atlantic Coast seaweeds.

[4] Based on the range of prices quoted in recent years for dried kelp (L. D. Pratt, Kelco Co., personal communication).

Table G5-10

Recent Kelp Harvest in Tons

Year	Northern California Beds (Bull Kelp)	Inshore Southern California Beds (Giant Kelp)	Southern California Offshore Island Beds (Giant Kelp)
1970	1,168	87,683	38,233
1971	329	123,130	32,100
1972	2,367	117,534	42,610

From: Hester (1974)

Table G5-11

PLAN OF UTILIZATION FOR THE LIVING MARINE RESOURCES OF CALIFORNIA (from FREY, 1971)

I. The following marine species do not require sport or commercial daily bay limits or quotas.

Plants	Crustaceans	Mollusks	Other invertebrates	Fish
Kelp	Rock crabs	JackKnife clams	Various species of "worms" used for bait	Grunion[1]
Agarophytes	Sand crabs	Octopus		Pacific hake
Porphyra	Shrimp, bay	Squid		Arrowtooth flounder
	Shrimp, brine			Flyingfish
	Shrimp, ghost			Jacksmelt
				Mudsucker
				Pacific pompano
				Pacific saury
				Queenfish
				Sanddab, longfin
				Sanddab, Pacific
				Sanddab, speckled
				Sharks, skates, and rays
				Shiner perch
				Staghorn sculpin
				Topsmelt
				Tuna, albacore
				Tuna, bluefin
				Tuna, skipjack
				White croaker

II. No commercial limits are necessary for the following marine species; however, daily bag limits are recommended for the sport angler.

Crustaceans	Mollusks	Fish	
Lobster	Abalone	California barracuda	California yellowtail
Market crab	Mussels	Halibut, California	Common dolphinfish
		Halibut, Pacific	Greenling, kelp
		Rockfish	Greenling, painted

Table G5-11 (cont'd)

II. (Continued)

Salmon
Surfperch
Surf smelt
Swordfish
White seabass
Blacksmith
Bonito, Pacific
Cabezon
California salema
Pacific tomcod
Rock wrasse
Sablefish
Sargo
Sculpin
Senorita
Sheephead
Sierra
Sole, bigmouth
Sole, Dover
Sole, English
Sole, Fantail

Greenling, rock
Groupers
Halfmoon
Lingcod
Mackerel, bullet
Mackerel, jack
Mackerel, Spanish
Ocean whitefish
Opaleye
Sole, petrale
Sole, rex
Sole, rock
Sole, scaley-fin
Sole, slender
Starry flounder
Striped mullet
Turbot, diamond
Turbot, C-O
Turbot, curlfin
Turbot, hornyhead
Turbot, spotted

III. The following marine species are set aside for sport utilization exclusively, and may not be taken commercially in California waters. Under certain conditions, some species may be imported for commercial purposes.

Mollusks

Goeduck clams
Pismo clams
Razor clams
Rock scallops

Fish

Giant sea bass
Kelp bass
Sand bass
Spotted sand bass

Striped marlin
Yellowfin croaker
Spotfin croaker
California corbina

Table G5-11 (cont'd)

IV. The following species should have harvest limits or quotas.

Crustaceans	Fish
Ocean shrimp	Anchovy
	Herring eggs on seaweed
	Yellowfin tuna

V. The following species should be fully protected, and moratoria have been or should be established on their harvest.

Mollusks	Fish
Speckled scallops	Garibaldi
	Pacific mackerel
	Sardine

VI. Selective population control to maintain healthy viable stocks may be necessary from time to time for the following species. Any control measures should be carried out under supervision of the California Department of Fish and Game.

Mammals
California sea lions
Steller sea lions
California sea otters
Harbor seals

VII. The following species should have both sport and commercial daily bag limits.

Mollusks	Fish
Littleneck clams	Monkeyface eel
Washington clams	Rock eel
Gaper clams	

VIII. Mariculture will be encouraged on both private and state owned lands.

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[1] This species generally does not enter the commercial catch and may be taken by sportsmen from June 1 to March 31 by hand only.

Table G5-12(Hester, 1974)

Tonnage of Jack Mackerel and Anchovies
Landed in Northwestern Baja California
1965-1971

Year	Jack Mackerel	Anchovies
1965	7,900	10,500
1966	6,467	14,678
1967	2,142	26,306
1968	1,774	17,262
1969	1,669	3,205
1970	230	3,405
1971	98	5,565

REFERENCES

REFERENCES

Ahlstrom, E. H. 1968. An evaluation of the fishery resources available to California fishermen. In the future of the fishing industry in the United States, Univ. Wash. Publ. Fish. New Ser. Vol. IV. p.65-80.

Anonymous. 1973. Value up, volume down in 1972 U.S. landings. Consumption Up. Mar. Fish. Rev. 35(5-6): 54.

Bell, R. R. 1971. California marine fish landings for 1970. Calif. Dept. Fish Game Fish Bull. 154: 1-50.

________. 1974. Statistical report of fresh, canned, cured, and manufactured fishery products for 1972. Calif. Dept. Fish Game Circ. No. 47: 1-19.

Bland, C. E. Jr. 1969. The jack mackeral *Trachurus symmeticus)* resource of the Eastern North Pacific Calif. Marine Res. Comm., Calif. Cooperative Oceanic Fishery Investigations 13: 45-52.

Bor (Bureau of Outdoor Recreation) Memo. 1973. Subject: Proposed call for nominations for possible lease sale of oil and gas lands offshore Southern California beyond the Channel Islands. To Director, Bureau of Land Management, Aug. 24, 1973.

California Department of Fish and Game Planning Team. 1973. Coastal county fish and wildlife resources and their utilization. Resources Agency of Calif., Dept. Fish Game, 258 p.

California Dept. of Parks and Recreation, 1971. Summary printouts 1969. February.

California Region Comprehensive Framework Study. 1971. Appx. XII. Recreation. Proposed by California Region Framework Study Committee for Pacific Southwest Inter-Agency Committee Water Resources Council. June.

California Statistical Abstract. 1972.

California, State of Dept. of Parks and Recreation. 1969-70. Statistical report 1969-70 fiscal year.

____________________________. 1971-72 Statistical report 1971-72 fiscal year.

____________________________. 1972-73 Statistical report 1972-73 fiscal year.

California, State of Dept. of Parks and Recreation. 1972. Resources report on Gaviota State Park. Unpublished file.

California Summary of Operations. 1974. State of California Division of Oil and Gas.

COMTHIRDFLT Inst. 3120.1 H.1973. Commander third fleet manual of fleet operating areas. San Francisco, Commander Third Fleet F. P. O.

Collins, R. A. 1973. The status of the California yellowtail resource and its management. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 16: 172-186.

Croker, R. S. 1968. The fish cannary industry of Baja California, Mexico. NMFS Foreign Fishing Leaflet #160.

CORRP(California Outdoor Recreation Resources Plan). 1972.

Duffy, J. M. 1973. Status of the spiny lobster. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 10: 241-253.

Ebert, E. E. 1973: Mariculture in California. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 18: 314-327.

Frey, H. W. (ed.). 1971. California's living marine resources and their utilization. Resources Agency of Calif., Dept. Fish Game, 148 p.

Ganssle, D. 1973. The status of the northern anchovy resource and its management. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 5: 112-123.

Green, R. E., and G. C. Broadhead. 1964. Costs and earnings of tropical tuna vessels based in California. Fish Ind. Res. 3(1): 29-45.

Gruen, Gruen, and Associates. 1972. A socioeconomic analysis of California's sport and commercial fishing industries. Report to Calif. Resources Agency. 106 p. (Gruen, Gruen, and Associates, San Francisco, Calif.)

Haugen, C. W. 1973. The status of the Pacific sardine resource and its management. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 13: 124-136.

Heimann, R. F. G., and J. G. Carlisle, Jr. 1970. The California marine fish catch for 1968 and historical review 1916-1968. Calif. Dept. Fish Game Fish Bull. 149: 1-70.

Hester, F. J. 1974. The living marine resources of Central and southern California and Baja, California. Informational Dept. for Western Oil and Gas Assoc. 161p.

Horn, M. H. 1974a. Fisheries. In A summary of knowledge of the Southern California Coastal zone and offshore areas. The Southern Calif. Ocean Studies Consortium, Vol. II.

Horn, M. H. 1974b. Fisheries resources. In a Summary of knowledge of The Southern California Coastal Zone and offshore areas. The Southern California Ocean Studies consortium, Vol. III.

Jow, T. 1973. Status of the Pacific hake resource and its management. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 9: 215-241.

Kato, S. 1972. Sea urchins: a new fishery develops in California. Mar. Fish. Rev. 34(9-10): 23-30.

Knaggs, E. H. 1973. Status of the jack mackerel resource and its management. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 11: 148-157.

Los Angeles County Regional Recreation Areas Plan. 1965.

Map # 18004, 1973. Southern California Sector offshore operating areas for sea and air U. S. Naval Oceanographic Office. Washington, D. C.

MacCall, A. 1973. The status of the Pacific mackerel resource and its management. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 12: 137-147.

McNeely, R. L. 1961. The purse seine revolution in tuna fishing. Pac. Fish., June, 1961: 27-58.

Messersmith, J. D. 1969. The northern anchovy *(Engraulis mordax)* and its fishery 1965-1968. Calif. Dept. of Fish and Game, Fish, Bull. 147: 120p.

Miller, D. J. and J. E. Hardwick. 1973. The status of the rockfish resource and its management. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 17: 284-313.

Murray, S. N. 1974. Benthic. algae and grasses. In A summary of knowledge of the Southern California coastal zone and offshore areas. The Southern California Ocean Studies Consortium, Vol.II.

National Park Service. 1970. Basic data: Channel Islands. Unpublished.

NOS. Maps # 5101 & 5202.1973. San Diego to Santa Rosa Island, Point Dume to Purisima Point. Washington, D. C., U. S. Dept. Commerce, National Ocean Survey.

Oliphant, M. S. 1974. Personal Communication phone conversations, Jan. 16, 1974 and Mar. 13, 1974.

__________. 1974. Unpublished file.

__________, and staff. 1973. California marine fish landings for 1971. Calif. Dept. Fish Game Fish Bull. 159: 1-49.

Orcutt, H. G. 1969. Bottomfish resources of the California Current System. Calif. Marine Res. Comm., Calif. Cooperative Oceanic Fishery Investigations 13:53-59.

Perrin, W. F., and B. G. Noetzel. 1970. Economic study of the San Pedro wetfish boats. Fish. Ind. Res. 6(3): 105-138.

Pinkas, L. 1970. The California marine fish catch for 1969. Calif. Dept. Fish Game Fish Bull. 153: 1-47.

__________. 1971. Bluefin Tuna food habits. Calif. Dept. of Fish and Game, Fish. Bull. 152: 47-63.

__________, M. S. Oliphant, and C. W. Haugen. 1968. Southern California marine sportfishing survey: private boats, 1964; shoreline, 1965-66. Calif. Dept. Fish Game Fish Bull. 143: 1-42.

San Diego County Comprehensive Planning Organization Open Space Study. 1972. An Open Space System for the San Diego region. April.

Schultze, D. L. 1973. The status of the California barracuda resource and its management. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 6: 187-204.

SCCWRP. 1973. The ecology of the Southern California Bight Implication for water quality management. Ch. 7, Coastal fish populations, p. 193-203. TR 104: 1-531. El Segundo, Calif.

Squire, J. L., Jr. (compiler). 1973. Proceedings of the state-federal marine fisheries research program planning workshop, California Department of Fish and Game and National Marine Fisheries Service, March 12-15, 1973, San Clemente, Calif. 327 p.

Stephens, J. S. 1972. Bay and inshore fish. In Proc. S. Calif. Coastal Zone Symp., Fullerton, Calif. 17-18 March 1972, p. 18-21.

Thayer, B. D. 1973. The status of the Pacific bonito resource and its utilization. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 7: 158-171

United California Bank, Research and Planning Division. 1973. 1974 Forecast.

United States Coast Piolot # 7. 1968. U. S. Dept. of Commerce, Washington, D. C. Government Printing Office.

U. S. Corps of Engineers. 1971. National Shoreline Study. California regional inventory. San Francisco.

U. S. Dept. of Commerce, Bureau of Census. 1972. County and city data book.

Ventura County Planning Department. 1974. Ventura County Coastal Study.

Wise, J. P. 1972. U. S. Fisheries: a view of their status and potential. Mar. Fish. Rev. 34(7-8): 9-19.

Young, P. H. 1969. The California partboat fishery 1947-1967. Calif. Dept. Fish Game Fish Bull. 145: 1-91.

______. 1973a. Partyboat logs show how skin and scuba divers fared - 1965 through 1970. Calif. Fish Game 59(1): 62-72.

______. 1973b. The status of the white seabass and its management. Calif. Dept. Fish Game Mar. Resources Tech. Rept. No. 15: 205-214.

APPENDIX 10

H. Environmental Problems

2. Past and Potential Sources of Water Quality Degradation

REFERENCES

Brown, R. P. 1970. Summary of ocean dumping on the California Bight 1931-1971. The Southern California Coastal Water Research Project.

Chow, T. J. and J. H. Earl. 1970. Lead aerosols in the atmosphere: increaseing concentrations. Science 169: 577-580.

COMTHIRDFLT. 1973. Commander Third Fleet Manual of Fleet Operating Areas. Command Third Fleet F. P. O. San Francisco Inst. 3120.1H.

Reed, W. H. and T. H. Bakker. 1974. A summary of knowledge of the Southern California coastal zone and offshore areas. Long Beach, Calif., Southern California Ocean Studies Consortium.

Smith, D. O. and R. P. Brown. 1971. Ocean disposal of barge - delivered liquid and solid wastes from U.S. Coastal cities. U.S. Environmental Protection Agency SW-19C. Washington, D. C., U.S. Government Printing Office, #5502-0035.

State of California Resources Agency - Air Resources Board. 1972. Air pollution in California, annual report 1972.

Los Angeles Air Pollution Control District. Smog alerts.

Southern California Coastal Water Research Project (SCCWRP). 1973. The ecology of the Southern California Bight: implications for water quality management. SCCWRP TR 104.

Southern California Coastal Water Research Project (SCCWRP). 1974. Coastal Water Research Project: annual report for the year ended 30 June 1974. El Segundo, California.

Storrs, P. N. 1973. Petroleum inputs to the marine environment from land sources. In: background papers for a workshop on inputs, fates, and effects of petroleum in the marine environment. National Academy of Science. prepared for; office of Naval Research Coast Guard.

U.S. Department of Commerce: Environmental Science Services Administration Coastal Geodetic Survey. 1968. Pacific Coast - California, Oregon, Washington, and Hawaii.

Young, D. R. 1975. A review of the chemical oceanography of the Southern California offshore region. In: proceedings of the recommendation for baseline research in Southern California relative to offshore resource development. Proceedings, special publication; Southern California Academy of Sciences.

APPENDIX 10

I. Historical and Projected Economic Growth

References

California State Office of Planning, University of California Institute of Marine Resources. 1965. California and Use of the Ocean, October.

Los Angeles County, Department of Agriculture. Los Angeles County Crop and Livestock Report 1972.

Orange County, Department of Agriculture. Agriculture crop report, Orange County 1971.

________________________________. Agriculture crop report, Orange County 1972.

San Diego County, Department of Agriculture. Agriculture crop and natural resources report 1972.

Santa Barbara County, Department of Agriculture. 1972 Agriculture Crop Report.

Security Pacific Bank, Research Dept. 1974 monthly summary of business conditions in the northern coastal counties of California, Volume 6, Number 8, August.

Security Pacific National Bank. 1971. Monthly summary of business conditions in Southern California. February.

______________________________. 1971. Monthly summary of business conditions in Southern California. September.

______________________________. 1973. Monthly summary of business conditions in Southern California. August.

______________________________. 1973. Monthly summary of business conditions in Southern California. October.

______________________________. 1973. Monthly summary of business conditions in Southern California. November.

______________________________. 1974. Monthly summary of business conditions in Southern California. January.

______________________________. 1974. Monthly summary of business conditions in Southern California. August.

State of California. California statistical abstract 1973.

State of California, Department of Finance, California statistical abstract 1972.

State of California, Department of Finance, Population Research Unit, 1974. Population projections for California Counties 1975 - 2020, Sacramento, California, 23 p. June.

State of California, Dept. of Food and Agriculture. 1973. California Agriculture, 1972.

State of California, Employment Development Department (EDD) previously (HRD) Human Resources Development. County labor market surveys 1971 - 1972.

Southern California Visitors Council, Newsrelease, Tourists bring 2 billion to Southern California in 1973.

United California Bank, Research and Planning Division. 1973, 1974 forecast.

University of California at La Jolla, Institute of Marine Resources. California and Use of the Ocean.

U.S. Department of Commerce. 1972. Population and economic activities in the United States and Standard metropolitan statistical areas historical and projected. 1950 - 2020.

United States Resource Council. 1972. OBERS Projections.

Ventura County, Department of Agriculture. Ventura County Agriculture Crop Report 1972.

APPENDIX 11

SUMMARY OF U.S. COAST GUARD REGULATIONS CONCERNING OFFSHORE STRUCTURES AS HAZARDS TO NAVIGATION

Appendix 11

The pertinent regulations summarized below are found in the Code of Federal Regulations, No. 33, Navigation and Navigable Waters, Subpart 67.

The varied depths of water and marine commerce traffic routes which exist in the waters over the Outer Continental Shelf, and in other waters, permits the classification of structures according to their location in such waters. The structures in the area seaward of the line of demarcation specified by the Commandant and published in the Federal Register are designated as Class "A". This designation includes OCS platforms.

General requirements for lights specify that where structures have a horizontal dimension of over 500 feet on any one side or in diameter, an obstruction light shall be required on each corner or 90° apart in the case of circular structures. Each light is to have a 360° lens. Where two or more obstruction lights are required by the size of the structure, they must be in the same horizontal plane and not less than 20 feet above mean high water.

They shall be installed at a manner that will permit a mariner to hold sight of at least one of them until he is within 50 feet of the structure. Class "A" structure lights shall be white, powered from a reliable power source and display a quick flash characteristic of approximately 60 flashes per minute. The lights shall be of sufficient candlepower as to be visible at a distance of five nautical miles 90% of the nights of the year and they shall be displayed at all times between sunrise and sunset, local time, commencing at the time construction of the structure is begun.

The fog signal shall have a frequency range above 100 cycles and a loudness level of 55 phons and shall be sounded every 20 seconds (sound 2 seconds, silent 18 seconds). For Class "A" structures this signal shall have an audible range of not less than two miles, with no wind, in all directions from the structure it marks, whenever visibility is less than five miles in any direction.

Changes in these rules may be permitted upon approval of the District Commander when warranted by circumstances such as proximity of structures.

APPENDIX 12

GEOLOGIC TIME CHART

GEOLOGIC TIME CHART

AGE DIVISIONS			TIME			
ERA	PERIOD	EPOCH	DURATION IN MILLIONS OF YEARS: ERA	PERIOD	EPOCH	BEGINNING MILLIONS OF YEARS AGO
CENOZOIC	QUATERNARY	RECENT	63.011	1.011	0.011	0.011
		PLEISTOCENE			2	2
	TERTIARY	PLIOCENE		62	12	13
		MIOCENE			12	25
		OLIGOCENE			11	36
		EOCENE			22	58
		PALEOCENE			5	63
MESOZOIC	CRETACEOUS		167	72		135
	JURASSIC			46		181
	TRIASSIC			49		230
PALEOZOIC	PERMIAN		370	50		280
	PENNSYLVANIAN			40		320
	MISSISSIPPIAN			25		345
	DEVONIAN			60		405
	SILURIAN			20		425
	ORDOVICIAN			75		500
	CAMBRIAN			100		600
PRE-CAMBRIAN	GRENVILLE OROGENY		4000			1000
	OLDEST KNOWN ROCKS IN NORTH AMERICA					3200
	OLDEST KNOWN ROCKS (MURMANSK AREA)					3400
	PROBABLE AGE OF THE EARTH					4600

APPENDIX 13

LIST OF SIGNIFICANT FELT EARTHQUAKES IN THE BORDERLAND REGION 1800 TO 1973

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973[1]

Year	Month and day	Local Time	Maximum R.F. Intensity[2]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2] For Santa Barbara Area	Remarks
1800---	11-22	1330	VIII	---------	Southern California	VIII(?)	Heavy damage at San Diego, San Juan Capistrano
				---------	---do--------------	VIII	Light damage at Santa Barbara Mission. Probably same earthquake as above, but no date given for Santa Barbara observation.
1812---	May	----	I -III(?)	---------	---do--------------	----------	Unconfirmed So. California "swarm" activity lasting 4.5(?) months.
	10-8 to 11-18	----	I - IX(?)	---------	San Juan Capistrano	----------	Shocks for 40 days (Probably a swarm on coast or offshore faults near Mission San Juan Capistrano). Especially hard shock on October 21.
	12-8	Morning	IX	---------	---do--------------	----------	Mission San Juan Capistrano destroyed with loss of 30-45 lives; 28 buried in rubble from collapse of massive stone church walls. Possible seaquake damaged Spanish ship at anchor 38 miles from Santa Barbara.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 --Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1812	12-21	1030	X	---------	Santa Barbara and Purisima Conception Missions.	IX - X	Santa Barbara and Purisima Conception Missions destroyed (adobe construction). Santa Ynez Mission heavily damaged. Tsunami broke along Santa Barbara coast; wave height unknown, but runup possibly as high as 30-50 feet at some points between Santa Barbara and Gaviota according to unconfirmed reports. Several "asphaltum springs" formed in the mountains.
1815	1-18 to 1-30	----	I - III(?)	---------	Santa Barbara	I - III (?)	Several small shocks felt (probably swarm of microearthquakes).
	7-8 to 7-9	----	I - III(?)	---------	---do---	I - III (?)	Six felt shocks (probably swarm of microearthquakes).
1852	11-27 to 11-30	----	IX - X	---------	No. Ventura County	-----------	Probably on either San Andreas or Big Pine fault 40-50 miles northeast of Santa Barbara.)

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973--Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1853---	1-29	----	---------	---------	Santa Barbara-------	------------	(Probably a local slight shock.)
	3-1	----	V(?)	---------	San Louis Obispo----	V(?)	Felt in Santa Barbara.
1854---	4-20 to 5-31	----	VI	---------	Santa Barbara-------	VI	(Probable earthquake swarm). Sea waves generated during largest shock of series on May 31 at 4:50 a.m. and many people were alarmed. The large shocks seem to have terminated the series.
1855---	6-25	1400	V	---------	---do--------------	V	Also felt strongly in Santa Maria.
	7-10	2015	IX	---------	Los Angeles--------	V	Tsunamis broke on coast at Point San Juan (Dana Point) which indicates possible movement of offshore faults.
1857---	1-8	----	VII(?)-VIII	---------	Santa Barbara------	VII-VIII	Several slight shocks and one severe shock. Many other Southern California shocks. This entry perhaps results from confused accounts of the following entry.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1857---	1-9	----	IX - X	---------	Fort Tejon----------	VIII	Roof of Mission at San Buenaventura (Ventura) fell in. All houses in Santa Barbara damaged according to unconfirmed reports. Several new springs formed near Santa Barbara. One of California's greatest earthquakes centered 50 miles east-northeast of Santa Barbara on San Andreas fault.
	3-4	1500	V	---------	Santa Barbara--------	V	Severe shock felt in Santa Barbara and Montecito.
1860---	4-16	1930	-------	---------	Fort Tejon-----------	III(?)	Felt in Santa Barbara.
1862-------		----	VIII(?)	---------	Goleta---------------	VII(?)	Livestock frightened; trees swayed; people stood with difficulty.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity 2/	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity 2/ For Santa Barbara Area	Remarks
1872---	3-26	0230	X	---------	Owens Valley--------	V(?)	Probably the greatest earthquake in California's recorded history. Shock felt over nearly all California and Nevada and parts of Utah and Arizona, possibly also over northern part of Mexico. Many widely distributed aftershocks within Inyo County also felt throughout large areas.
1875---	12-21	----	---------	---------	Santa Barbara-------	---------	(Probably a local slight shock).
1877---	6-23	2350	III -IV(?)	---------	---do---------------	III-IV(?)	Three shocks; also felt in Bakersfield.
1878---	1-8	----	---------	---------	---do---------------	III(?)	(Probably a local slight shock).
1880---	4-12	0440	V	---------	Los Angeles---------	IV(?)	Severe effects along San Gabriel River. Also felt at Riverside(?) and had about same intensity at Ventura.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity [2]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2] For Santa Barbara Area	Remarks
	4-12	0803	V	---------	Ventura County------	IV(?)	Probably a severe shock in vicinity of San Buenaventura (Ventura & lands to northeast).
	11-12	2230	---------	---------	Santa Barbara-------	III(?)	(Probably a local slight shock).
1881---	8-30	1900	III	---------	---do---------------	III	Two slight shocks.
1883---	9-5	0430	VI	---------	Ventura-------------	V(?)	Strong Shock felt from Santa Barbara to Los Angeles.
	9-13	1430	IV	---------	Santa Barbara-------	IV	Small quake lasting 5 seconds.
1884---	8-2 to 8-4	----	III	---------	---do---------------	III(?)	A few very slight shocks felt.
1885---	4-7	0200	III	---------	---do---------------	III(?)	Also felt at Ventura and possibly at Bakersfield.
	6-14	0314	V	---------	Ventura-------------	IV(?)	A moderate earthquake felt also at Los Angeles.
	7-9	0120 to 0815	V	---------	Santa Barbara-------	V	A limited swarm of five moderate earthquakes. Felt shocks were of long duration, awakened most sleepers.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1890---	(?)	----	VI(?)	---------	Santa Barbara-------	V(?)	"Quite a heavy shock."
1893---	4-4	1140	VIII-IX	---------	Pico Canyon---------	V(?)	An intense local shock centered near Newhall, 35 miles north of Los Angeles. Strongly felt at Ventura, San Bernardino, and Mojave. Felt only lightly at Los Angeles and Santa Ana.
	5-18	1635	VII(?)	---------	Ventura-------------	VI(?)	Widely felt shock, most severe southeast of Ventura. Felt from San Diego to Lompoc and inland to San Bernardino. No damage reports. Possible submarine origin off Ventura coast.
	6-1	0400	VII(?)	---------	Santa Barbara-------	VII(?)	Considerably heavier than event on May 18, 1893. Also felt in Ventura and Ojai. Followed by light aftershocks.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity 2/	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity 2/ For Santa Barbara Area	Remarks
1894---	7-29	2112	VII	---------	So. California------	V(?)	Widely felt earthquake, most severe at Mojave and Los Angeles.
1895---	7-26	1610	III(?)	---------	Santa Barbara-------	III(?)	Local slight shock.
	12-23	2130	III(?)	---------	---do---------------	III(?)	Local slight shock.
1897---	6-24 to 7-19	----	III(?)	---------	Santa Barbara and Vicinity	III(?)	A few light shocks and two strong shocks.
1898---	5-29 to 6-3	----	V	---------	Santa Ynez Valley---	III(?)	One light and one heavy shock felt in Santa Barbara and vicinity. Heavy shaking at 2200 on June 3 felt throughout Santa Ynez Valley. Heaviest shock for some years at Santa Barbara.
1902---	2-7 to 2-9	----	VI(?)	---------	Santa Barbara-------	VI(?)	One light shock February 7 then by moderate shock on February 9 causing general alarm but no reported damage.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity 2/	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity 2/ For Santa Barbara Area	Remarks
1902---	7-21	---	III(?)	---------	Pine Crest----------	-----------	(Probably slight local shock near Pine Crest, Santa Barbara county).
	7-27	2257	VIII-IX	---------	Los Alamos----------	III(?)	Severe local shock probably centered near Los Alamos, 35 miles west-northwest of Santa Barbara. Considerable local damage at Lompoc and Los Alamos. No damage reported at Santa Barbara.
	7-27 to 8-14	----	VIII-IX	---------	Los Alamos, Santa Barbara, Lompoc, Santa Maria and San Louis Obispo	VII(?)	Unusual widespread swarm of felt shocks attaining local intensities as high as R.F. IX. Several events felt at Santa Barbara but no reports of damage there. Heaviest intensities and most frequent reports concentrated at Los Alamos, 45 miles west-northwest of Santa Barbara.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
							Shocks probably originated on various western extensions and branches of Santa Ynez fault zone. Heavy shocks near Los Alamos on July 31, preceded by 5 days of frequent minor shocks; drove nearly the entire population away.
1902---	9-10	2130	V	---------	Los Alamos----------	III(?)	Severe shock preceded by days of light shocks.
	10-21	----	IV(?)	---------	---do---------------	II(?)	Three shocks, the first quite severe. No damage reports. Felt in Lompoc.
	12-12	----	VIII	---------	---do---------------	III(?)	All of north Santa Barbara County shaken by severe quakes. Light damage at Los Alamos and Santa Maria. Felt at Lompoc, San Luis Obispo, and Santa Barbara.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1904---	10-14	-----	III(?)	---------	Ventura-------------	-----------	(Probably slight local shock).
	10-15	-----	IV(?)	---------	Los Angeles---------	III(?)	Light shock probably centered near Los Angeles. Felt at Santa Barbara and Sierra Madre.
	10-20	-----	III(?)	---------	Ventura-------------	-----------	(Probably slight local shock at Snedden Ranch near Ventura).
1905---	3-18	2040	VI	---------	Bakersfield---------	II(?)	Shocks were heaviest at McKittrick and Sunset oil fields. Flow of oil wells was increased. Shock felt at Nordhoff (Ojai), in Ventura County 25 miles east of Santa Barbara.
1907---	7-3	0108	III(?)	---------	Ojai----------------	II(?)	Slight local shock near Ojai felt at Santa Barbara.
	7-28	2110	II(?)	---------	Pine Crest----------	-----------	Slight local shock.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1907---	August	----	III(?)	---------	Pine Crest----------	II(?)	"Slight earthquake felt on same day and hour as at Santa Barbara City."
	9-19	1745	VII-VIII	---------	San Bernardino------	III(?)	Large shock probably centered near San Bernardino, but felt throughout most of Southern California. Light shaking at Montecito, near Santa Barbara.
	12-27	0115	III(?)	---------	Santa Barbara-------	III(?)	A light local shock also felt at Ventura and Ojai.
1909---	1-23	0658	III(?)	---------	---do---------------	III(?)	A light local shock also felt at Pine Crest.
	7-2	2330 (?)	III(?)	---------	---do---------------	III(?)	A sharp local shock also felt at Montecito.
	7-2 to 7-31	----	IV	---------	---do---------------	II-IV(?)	Several slight to moderate shocks felt in Santa Barbara area. One heavy shock July 16, also felt at Los Angeles.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1910---	5-15	0747	VII-VIII	---------	Riverside County----	II(?)	Widely felt earthquake in Southern California. (Probably slight at Ventura and Santa Barbara)
	November	----	III(?)	---------	Santa Barbara-------	III(?)	Two slight quakes
1911---	3-28	2025	V-VI	---------	San Miguel Island---	III(?)	Moderate quake centered near San Miguel Island, Santa Barbara County. Felt slightly at Santa Barbara.
1911---	5-10	0500 to 0540	IV(?)	---------	Oxnard--------------	II(?)	Three light shocks centered near Oxnard, Ventura County. Felt slightly at Los Angeles and at Ojai.
1918---	12-14	0200	IV	---------	San Miguel Island---	II(?)	(Probably slight local event)
	4-21	1432	IX-X	---------	San Jacinto---------	II-III(?)	Strong shock felt over wide area of Southern California and western Arizona. Very slightly felt at Los Olivos, Santa Barbara County, 30 miles northwest of Santa Barbara.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity For Santa Barbara Area	Remarks
1919---	1-25	1429	V	---------	Tejon Pass----------	II	Sharp quake near Tejon Pass, felt at Ojai, Ventura, Bakersfield, and Maricopa with intensity of III to IV. Weak but perceptible at Santa Barbara and Los Angeles.
	2-16	0757	VII	---------	San Andreas fault south of Maricopa--	II(?)	Strong shock felt over wide area. Intensity was IV at San Luis Obispo and Los Angeles. Los Olivos and Ojai reported intensities III and V respectively.
	8-26	0412	V+ (?)	---------	Santa Barbara County	V(?)	Generally felt at Santa Barbara and from San Luis Obispo to Ojai. No damage reported.
1920---	6-18	0208	VIII(?)	---------	Los Angeles region--	III(?)	Sharp quake, felt also on Santa Catalina Island. (Reports seem to indicate an origin on submarine fault in San Pedro Channel.)

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973--Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1920---	6-21	1848	VIII-IX	----------	Inglewood, Los Angeles County	II(?)	High intensity of VIII to IX near the source in small area of the western part of Inglewood. Barely felt at Ventura.
1924---	12-30	----	IV(?)	----------	Santa Barbara-------	IV(?)	Two "sharp, heavy blows."
1925---	1-28	0930	IV	----------	Ojai-----------------	II(?)	Two slight shocks.
	6-29	0642	IX	6.3	Santa Barbara-------	IX	Strong, destructive local earthquakes practically destroyed the business section of Santa Barbara. Felt from Watsonville on the northwest to Santa Ana on the southeast and inland to Mojave.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973--Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
	6-29 to 10-9	----	---------	---------	Santa Barbara and Ventura Counties	---------	Forty-two earthquake reports from Santa Barbara area. Most of these were aftershocks associated with the event of June 29. About 32 reports from Santa Barbara alone yield a count of 10 strong aftershocks. Only the aftershocks of some special significance will be listed separately.
	7-3	0838	VII(?)	---------	Santa Barbara-------	VII(?)	Also felt at Pasadena, III; Ojai, III; and Ventura IV(?).
	7-3	1021	VII(?)	---------	---do----------------	VII(?)	Sharp and heavy. Instrumental records indicate this was strongest Santa Barbara aftershock.
1925	7-5	0400 to 2300	II-III(?)	---------	Santa Barbara-------	II-III(?)	Eleven-shock swarm of felt tremors. A thermograph instrument recorded almost continuous vibrations between 7 and 10 am.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1925---	7-6 to 7-9	----	---------	---------	---do----------------	-----------	Continued activity during aftershock sequence.
	7-30	----	IV(?)	---------	Santa Barbara, Ventura & vicinity	IV(?)	Several felt earthquakes.
	8-12	----	V	---------	Ojai-----------------	III(?)	Abrupt bumping also felt at Ventura, III(?).
	8-13	----	III(?)	---------	Santa Barbara-------	III(?)	(Several light shocks)
	10-30	----	III(?)	---------	---do----------------	III(?)	"Little jolt," followed by sharp shock. Second event felt at Ventura also.
1926---	1-12	0215	IV	---------	Ojai-----------------	III(?)	Abrupt bumping, awakened many sleepers. Felt at Santa Barbara.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1926---	2-18	1018	VI+	---------	Origin at sea southwest of Ventura	VI(?)	Windows broken at Santa Barbara school, water pipe broken in roundhouse. Felt along coast from San Luis Obispo on northwest to south of Santa Ana, a distance of 200 miles. No mention of tsunami.
	5-3	0553	VI(?)	---------	Origin at sea southwest of Port Hueneme, Ventura County	III(?)	Felt at San Luis Obispo, 100 miles to northwest. Ventura intensity VI(?). Slight tremor at Santa Barbara. No mention of tsunami.
	5-14	1000(?)	IV+ (?)	----------	Ojai -------------	III(?)	Also felt as slight shock at Santa Barbara.
	6-24	0730	V	----------	Santa Barbara------	V	Two shocks, like sharp blows, felt by all; pendulum clocks stopped.
	6-27	1730	IV	----------	Ventura------------	----------	Two shocks, abrupt; bumping; felt by many.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity 2/	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity 2/ For Santa Barbara Area	Remarks
1926	6-29	1521	VII-VIII	---------	Santa Barbara-------	VII-VIII	Shock from possible offshore fault exactly one year following destructive 1925 earthquake. Child killed by falling chimney. Glass broken, cracks in walls enlarged; surf agitated violently (probably due to seaquake, possible due to small tsunami). Felt from Los Angeles to Buellton, 30 miles west-northwest from Santa Barbara, where shock was felt by all; plaster was cracked.
	7-3	1500	II	---------	---do---------------	II	Four slight shocks within 20-minute period. Felt by very few.
	7-6	0945	V	---------	---do---------------	V	Three shocks felt by many. Buildings swayed.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973 -- Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity 2/	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity 2/ For Santa Barbara Area	Remarks
1926---	8-6	0942	IV	---------	Santa Barbara region	IV	Sharp quake at Santa Barbara, also felt at Ojai and Ventura.
	8-8	2012	V+ (?)	---------	Santa Barbara-------	V+ (?)	Shook dishes from shelves and caused noticeable swinging of chandeliers.
	9-28	0949	V(?)	---------	Ventura-------------	IV(?)	Located at sea southwest of Ventura. Felt at Santa Barbara and Ojai also.
	12-19(?) to 12-20 (?)	----	III+	---------	---do---------------	II(?)	Two slight shocks one hour and 40 minutes apart.
1927	5-15(?)	0320	V +	---------	---do---------------	III(?)	Pronounced shock which cracked windows in Ventura. Probably originated on offshore fault south of Port Hueneme.
	8-4	0424	VI+	---------	Santa Monica Bay-----	IV(?)	Origin located offshore. Felt from Ventura to Anaheim on Coast and to San Bernardino.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973--Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity 2/	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity 2/ For Santa Barbara Area	Remarks
1927---	8-26	0440	V +(?)	---------	Santa Barbara-------	V +(?)	Two sharp shocks, causing much alarm. Also felt at Ventura.
	11-4	0300 to 0330	V(?)	---------	Point Arguello,----- Lompoc	II(?)	Four shocks preceding strong event at 0551.
	11-4	0551	IX-X(?)	7.5	At sea west of Point Arguello	VI-VII	Largest earthquake in California following 1906 San Francisco event until July 21, 1952 (7.7). Much stronger shock than 1925 Santa Barbara event. Seaquakes generated during some larger aftershocks. Small tsunami broke along coast at surf and Fort San Luis. Tsunami also recorded on tide gages at San Diego and Santa Barbara. Felt from Morgan Hill on northwest to Whittier on southeast. Many aftershocks, including some destructive tremors occurred through December 31,1927, and later.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973--Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1927---	11-18	1932	VI-VII	---------	Santa Maria---------	IV(?)	
1930---	8-5	0325	VIII	---------	Santa Barbara-------	VIII	
1933---	3-10	1754	IX+	6.3	Long Beach----------	III(?)	An event of moderate magnitude similar to Santa Barbara 1925 quake, but $40 million in damages and 115 lives lost because of proximity to heavily populated area with many poorly constructed buildings and poor foundation conditions.
1941---	6-30	2351	VII-IX	5.9	Santa Barbara-------	VIII	Most damaging earthquake since 1925, with origin in Santa Barbara Channel area. Total damage about $100,000. Many structures affected had been damaged in 1925 and not adequately repaired.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973--Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2] For Santa Barbara Area	Remarks
1945---	4-1	1543	IV	5.4	Santa Rosa Island---	IV	Felt along coastal area from Santa Maria, south through Santa Barbara and Ventura to Simi.
1949---	8-27	0652	VI	4.9	Near Point Conception---------	V	Felt in coastal region of San Luis Obispo and Santa Barbara Counties. Strong effects at Arlight and Lompoc.
1952---	7-21	0352	X	7.7	Kern County--------	VIII(?)	Largest earthquake in the continental United States since 1906. Strongly felt along Southern California coast, including Santa Barbara area. Centered about 60 miles northeast of Santa Barbara. Caused damage to buildings in Santa Barbara with losses estimated at $400,000.
1954---	8-26	0548	VI(?)	4.8	Near Anacapa Island	VI(?)	People awakened by short, sharp shock at Santa Barbara. No damage other than plaster was shaken.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973--Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity[2/]	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity[2/] For Santa Barbara Area	Remarks
1957---	3-18	1056	VI	4.7	South of Oxnard-----	III(?)	Felt over 3000 square miles of Southern California. Minor damage occurred at Oxnard. Port Hueneme, and Ventura.
1958---	3-13	2125	VI	4.7	Off Carpinteria-----	V	Felt over 5000 square miles of Santa Barbara coast area. Slight damage in Carpinteria.
1962---	9-16	1012	V	4.0	Near Santa Barbara--	V	Felt principally in Santa Barbara County.
1968---	7-4	1645	VI(?)	5.2	Santa Barbara Channel-----------	VI	Largest shock of an earthquake swarm (from June 26 to Aug.3). Felt over 8000 square miles. Minor damage sustained at Coleta, Carpinteria and Santa Barbara. Many shocks of this swarm also felt over wide area.
1971---	2-9	0600	IX-X	6.6	14 km NNE of San Fernando------	V	Felt throughout Southern California, Nevada, Arizona, northern Mexico. Due to proximity to populated areas, 64 lives lost and tangible damage amounted to $553 million.

See footnotes at end of table

Table 13-1. List of Significant Felt Earthquakes in the Borderland Region, 1800 to 1973--Cont'd

Year	Month and day	Local Time	Maximum R.F. Intensity 2/	Magnitude	General Location of Maximum Intensity Area and (or) Epicentral Area	R.F. Intensity 2/ For Santa Barbara Area	Remarks
							Nearly 25,000 buildings damaged. several newly constructed hospitals severely damaged, one old hospital collapsed, 5 highway overpasses collapsed, 7 additional overpasses damaged, 5 dams damaged. Many aftershocks.
1973---	2-21	0646	VII	6.0	Point Mugu----------	IV	Felt throughout much of Southern California. Preliminary estimate of damage $1 million. Some major structural damage in Oxnard, but most damage minor. No deaths, injuries minor.
1973---	8-6	1629	VI(?)	4.8	Near Anacapa-------- Island	VI(?)	

1/ The primary source for the information presented is the Catalog of Townley and Allen (1939); data after 1928 have been compiled from various sources, especially the annual issues of "U.S. Earthquakes." Question-mark entries are used for original queried entries or where present author entered an interpretation based on incomplete data. Remarks enclosed in parentheses are interpretations drawn from incomplete accounts.

2/ The most commonly used form of the Rossi-Forel (R.F.) scale reads as follows (Richter, 1958):

I. Microseismic shock.--Recorded by a single seismograph or by seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer.

II. Extremely feeble shock.--Recorded by several seismographs of different kinds; felt by a small number of persons at rest.

III. Very feeble shock,--Felt by several persons at rest; strong enough for the direction or duration to be appreciable.

IV. Feeble shock.--Felt by persons in motion; disturbance of movable objects, doors, windows, cracking of ceilings.

V. Shock of moderate intensity.--Felt generally by everyone; disturbance of furniture and beds, ringing of some bells.

VI. Fairly strong shock.--General awakening of those asleep, general ringing of bells, oscillation of chandeliers, stopping of clocks, visible agitation of trees and shrubs, some startled persons leaving their dwellings.

VII. Strong shock.--Overthrow of movable objects, fall of plaster, ringing of church bells, general panic but no damage to buildings.

VIII. Very strong shock.--Fall of chimneys, cracks in the walls of buildings.

IX. Extremely strong shock.--Partial or total destruction of some buildings.

X. Shock of extreme intensity.--Great disaster, ruins, disturbance of the strata, fissures in the ground, rock-falls from mountains.

APPENDIX 14

MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITIES

Modified Mercalli scale of earthquake intensities.

THE MERCALLI INTENSITY SCALE

(As modified by Charles F. Richter in 1956 and rearranged)

If most of these effects are observed	*then the intensity is:*
Earthquake shaking not felt. But people may observe marginal effects of large distance earthquakes without identifying these effects as earthquake-caused. Among them: trees, structures, liquids, bodies of water sway slowly, or doors swing slowly.	*I*
Effect on people: Shaking felt by those at rest, especially if they are indoors, and by those on upper floors.	*II*
Effect on people: Felt by most people indoors. Some can estimate duration of shaking. But many may not recognize shaking of building as caused by an earthquake; the shaking is like that caused by the passing of light trucks.	*III*
Other effects: Hanging objects swing. *Structural effects:* Windows or doors rattle. Wooden walls and frames creak.	*IV*
Effect on people: Felt by everyone indoors. Many estimate duration of shaking. But they still may not recognize it as caused by an earthquake. The shaking is like that caused by the passing of heavy trucks, though sometimes, instead, people may feel the sensation of a jolt, as if a heavy ball had struck the walls. *Other effects:* Hanging objects swing. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. *Structural effects:* Doors close, open or swing. Windows rattle.	*V*
Effect on people: Felt by everyone indoors and by most people outdoors. Many now estimate not only the duration of shaking but also its direction and have no doubt as to its cause. Sleepers wakened. *Other effects:* Hanging objects swing. Shutters or pictures move. Pendulum clocks stop, start or change rate. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Liquids disturbed, some spilled. Small unstable objects displaced or upset. *Structural effects:* Weak plaster and Masonry D* crack. Windows break. Doors close, open or swing.	*VI*
Effect on people: Felt by everyone. Many are frightened and run outdoors. People walk unsteadily. *Other effects:* Small church or school bells ring. Pictures thrown off walls, knicknacks and books off shelves. Dishes or glasses broken. Furniture moved or overturned. Trees, bushes shaken visibly, or heard to rustle. *Structural effects:* Masonry D* damaged; some cracks in Masonry C*. Weak chimneys break at roof line. Plaster, loose bricks, stones, tiles, cornices, unbraced parapets and architectural ornaments fall. Concrete irrigation ditches damaged.	*VII*
Effect on people: Difficult to stand. Shaking noticed by auto drivers. *Other effects:* Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Furniture broken. Hanging objects quiver. *Structural effects:* Masonry D* heavily damaged; Masonry C* damaged, partially collapses in some cases; some damage to Masonry B*; none to Masonry A*. Stucco and some masonry walls fall. Chimneys, factory stacks, monuments, towers, elevated tanks twist or fall. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off.	*VIII*
Effect on people: General fright. People thrown to ground. *Other effects:* Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. Steering of autos affected. Branches broken from trees. *Structural effects:* Masonry D* destroyed; Masonry C* heavily damaged, sometimes with complete collapse; Masonry B* is seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Reservoirs seriously damaged. Underground pipes broken.	*IX*
Effect on people: General Panic. *Other effects:* Conspicuous cracks in ground. In areas of soft ground, sand is ejected through holes and piles up into a small crater, and, in muddy areas, water fountains are formed. *Structural effects:* Most masonry and frame structures destroyed along with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes and embankments. Railroads bent slightly.	*X*
Effect on people: General panic. *Other effects:* Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. *Structural effects:* General destruction of buildings. Underground pipelines completely out of service. Railroads bent greatly.	*XI*
Effect on people: General panic. *Other effects:* Same as for Intensity X. *Structural effects:* Damage nearly total, the ultimate catastrophe. *Other effects:* Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air.	*XII*

* Masonry A.	Good workmanship and mortar, reinforced, designed to resist lateral forces.
Masonry B.	Good workmanship and mortar, reinforced.
Masonry C.	Good workmanship and mortar, unreinforced.
Masonry D.	Poor workmanship and mortar and weak materials, like adobe.

APPENDIX 15

REPORT OF THE CALIFORNIA PARTY BOAT FLEET STATEWIDE 1972

TABLE 15-1

Statewide Commercial Partyboat Catch by Species (Not including anchored barges) 1963–1972 *

Species	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Barracuda, California	483,699	303,070	443,304	892,697	470,480	372,246	358,518	373,801	50,474	38,243
Bass, kelp and sand	1,219,344	1,103,394	1,230,313	1,278,939	1,003,914	1,317,963	1,246,175	922,260	948,121	842,681
Bonito, Pacific	775,719	1,298,804	806,322	644,415	349,952	1,102,936	1,130,241	651,898	152,795	418,984
Cabezon	9,726	6,491	7,575	10,293	5,419	4,349	4,583	6,372	4,611	11,452
Halibut, California	125,669	141,465	118,213	88,726	63,582	54,663	27,634	29,968	10,598	8,140
Lingcod	27,513	25,263	33,260	44,676	43,559	42,449	32,693	61,833	63,239	103,965
Mackerel, jack	9,342	6,577	25,619	19,027	16,236	13,588	11,272	15,725	10,611	5,913
Mackerel, Pacific	146,560	101,219	151,896	205,090	108,366	78,933	120,036	129,770	224,223	245,882
Rockfish	962,659	966,801	1,347,430	1,688,718	1,894,057	2,102,859	1,978,981	2,663,882	2,222,943	3,054,959
Salmon	72,457	92,021	51,677	70,151	84,946	127,584	111,389	98,301	130,812	151,595
Sculpin	53,896	73,844	71,888	69,851	63,280	59,863	63,011	82,522	84,913	65,886
Seabass, white	19,800	14,901	9,775	3,972	3,385	4,138	4,056	4,359	5,265	3,858
Sheephead, California	18,443	26,822	41,651	52,967	42,676	33,075	49,626	39,464	38,300	33,541
Tuna, albacore	158,372	112,358	99,771	74,680	96,497	129,710	48,887	112,106	160,361	86,890
Tuna, bluefin	737	693	92	1,998	3,166	1,231	1,470	1,833	749	1,470
Whitefish, ocean	6,231	6,949	13,810	15,587	18,184	22,155	36,474	40,990	29,800	24,632
Yellowtail	45,705	39,104	18,367	80,163	31,392	58,049	79,202	97,376	44,608	59,031
All others	142,630	114,400	163,595	166,470	145,073	205,410	421,327	298,375	421,729	305,283
Total number of fish	**4,278,502**	**4,434,176**	**4,634,558**	**5,408,420**	**4,444,164**	**5,731,201**	**5,725,575**	**5,630,835**	**4,604,152**	**5,462,405**
Number of anglers	643,155	695,445	688,103	857,000	780,102	849,654	802,811	873,327	728,126	792,618

* See Fish Bulletin 121 for historical records 1936-1961.

TABLE 15-2

Recorded Catch of Live Bait for Saltwater Sportfishing 1968-1972

	Thousands of pounds[1]				
Species	1968	1969	1970	1971	1972
Anchovy................	14,353	10,627	12,210	12,774	11,700
Mackerel, jack.........	158	103	...	9	5
Mackerel, Pacific......	...	8	...	1	...
Sardine, adult.........	57	34	...	...	T
Sardine, juvenile......	...	...	6	T	T
Squid..................	23	9	...	10	...
Miscellaneous[2].........	57	...	4	...	16
Total pounds........	14,648	10,781	12,220	12,794	11,721
Number of Vessels[3].....	19	10	11	14	12

[1] Weights are estimated from voluntary records. They should be regarded as minimal because some fishermen do not supply catch information.

T Less than 500 pounds.

[2] Consists primarily of queenfish and white croaker.

[3] The number of live bait fishing vessels for which landings were reported. These numbers differ slightly from those in previous catch bulletins, since the earlier landing records, as submitted sometimes included the catch of more than one boat.

TABLE 15–3

NUMBER OF FISH BY SPECIES, ANGLER DAYS, ANGLERS, AND ANGLER HOURS REPORTED AND NUMBER OF MOBILE BOATS REPORTING CALIFORNIA PARTYBOAT FLEET, 1947–1969

Species	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Albacore	11,445	15,414	22,692	118,087	75,924	187,267	23,363	20,098	78,688	65,814	41,540	6,482	39	76,075	181,891	229,314	158,372	112,358	99,771	74,680	96,497	120,710	48,887
Barracuda, California	677,449	384,056	366,123	256,367	269,545	336,862	170,550	282,552	154,962	87,603	577,184	782,723	1,195,585	755,408	391,884	335,507	483,699	303,070	443,304	892,697	470,480	372,246	358,518
Bass, giant sea	160	439	212	179	261	92	135	102	162	74	151	203	184	228	310	390	598	353	580	548	622	496	653
Bass, kelp, sand	682,789	630,223	796,959	619,397	781,609	536,075	711,395	876,667	497,343	470,362	609,071	653,671	428,126	478,656	613,604	789,149	1,219,344	1,103,394	1,230,313	1,278,939	1,603,914	1,317,963	1,246,175
Bass, striped	†	†	†	†	†	†	†	†	†	†	†	†	†	•30,856	•42,357	•39,682	•58,551	34,163	16,488	44,869	23,791	23,058	20,091
Bonito, Pacific	36,496	14,519	5,372	2,359	14,475	7,649	6,321	70,078	22,409	61,404	258,555	422,568	776,386	1,199,919	849,426	798,725	775,719	1,298,804	806,322	614,415	349,952	1,102,936	1,130,241
Cabezon	9,886	14,590	14,125	15,971	18,029	10,847	9,650	13,132	12,366	18,195	14,479	9,909	5,329	2,516	2,639	4,538	9,726	6,491	7,575	10,293	5,419	4,349	4,583
Croaker, white	58,034	89,825	121,053	76,765	62,945	77,948	57,606	66,964	27,349	16,289	8,648	20,000	6,895	8,633	21,782	27,256	37,225	23,269	21,448	17,285	20,590	10,906	15,273
Croaker, yellowfin	8,166	3,667	3,032	999	663	708	1,367	2,411	595	1,099	275	95	132	275	325	778	562	993	1,386	1,619	645	211	1,351
Dolphinfish	15	--	--	1	--	2	--	12	--	2	2,805	--	4	1	3	--	139	4	341	48	198	929	170
Flatfish, miscellaneous	13,012	16,513	21,158	29,437	48,998	35,677	64,872	48,410	39,136	23,912	19,390	9,265	7,755	5,835	9,316	8,956	8,005	14,419	15,755	20,228	24,282	22,666	23,485
Halibut, California	104,436	143,462	104,639	85,935	59,295	34,158	34,292	59,674	35,802	21,661	10,795	16,192	25,365	48,310	108,011	118,966	125,669	141,365	118,213	88,726	63,582	54,663	27,634
Lingcod	22,011	24,406	26,131	23,868	24,052	17,389	13,011	22,940	29,113	37,649	38,012	39,801	31,206	28,232	23,466	25,399	27,513	25,263	33,260	44,676	43,559	42,449	32,693
Mackerel, jack	4,505	2,351	2,932	557	202	4,395	196,280	19,407	39,473	23,493	6,878	27,867	11,820	8,537	28,891	9,029	9,342	6,577	25,619	19,027	16,236	13,588	11,272
Mackerel, Pacific	148,041	203,012	95,158	66,969	47,188	76,568	61,467	315,037	151,018	121,136	151,960	136,607	88,952	79,370	113,988	116,738	146,560	101,219	151,896	205,090	108,366	78,933	120,036
Marlin	37	58	28	115	58	57	4	9	6	32	22	84	349	9	8	2	37	48	46	40	81	60	66
Rockfish	193,652	410,665	570,637	679,164	721,808	705,761	696,480	1,149,367	1,737,707	2,036,708	1,395,151	1,561,132	1,177,979	1,015,673	898,641	956,438	962,659	966,801	1,347,430	1,688,718	1,894,057	2,102,859	1,978,981
Sablefish	9,159	3,546	45	96	581	87	6,487	36,724	15,992	5,177	271	39	9	39	622	2,231	1,232	4,722	8,601	21,693	6,388	4,099	2,448
Salmon	5,018	11,209	23,057	56,337	71,970	86,472	98,723	119,911	128,978	114,505	44,701	52,676	55,945	37,941	42,965	87,612	72,457	92,021	51,677	70,151	84,946	127,584	111,389
Sculpin	26,062	52,554	37,030	53,419	35,721	39,068	28,952	33,462	28,613	36,558	13,473	13,743	11,477	15,111	26,672	33,314	53,896	73,844	71,888	69,851	63,280	59,863	63,011
Seabass, white	20,724	24,078	65,545	54,718	44,367	41,043	28,182	41,588	30,103	19,755	19,030	34,039	10,593	15,697	14,082	14,564	19,800	14,901	9,775	3,972	3,385	4,138	4,056
Sheephead, California	13,004	17,261	15,440	14,281	20,416	16,481	17,349	21,499	14,102	14,789	15,105	18,120	17,146	11,541	15,210	13,488	18,443	26,822	41,651	52,967	42,676	33,075	49,626
Sturgeon	‡	‡	†	‡	‡	‡	‡	--	--	2	--	--	2	--	1	1	3	832	1,731	1,874	2,258	1,653	1,911
Tuna, Bluefin	2,194	104	1,941	27	7,142	145	4,276	966	8,179	34,187	6,428	884	1,330	97	2,268	2,453	737	693	92	1,998	3,166	1,231	1,470
Tuna, Yellowfin	137	18	11	6	56	34	--	--	1	78	325	13	4	2,124	21	3	80	103	101	241	10,801	8,499	4,210
Tuna, skipjack	698	460	9	31	132	38	279	50	10	13	6,453	491	514	378	11	40	8,149	3,961	2,142	1,012	1,656	4,250	9,998
Whitefish, ocean	5,160	14,124	14,576	14,925	8,828	10,003	4,963	9,952	9,508	7,951	4,389	6,143	5,608	5,850	6,647	6,157	6,231	6,949	13,810	15,587	18,184	22,155	36,474
Yellowtail, California	6,948	13,028	17,710	6,971	23,721	59,263	27,702	40,872	36,468	29,198	242,686	123,384	457,350	254,969	42,367	21,826	45,705	39,104	18,367	80,163	31,392	58,049	79,202
All others	11,194	20,437	13,879	13,432	12,658	22,044	16,452	22,653	15,800	15,349	11,808	14,749	12,191	7,754	13,225	13,437	28,049	31,503	94,976	57,003	53,758	128,583	341,671
Total	2,070,432	2,110,019	2,339,794	2,190,413	2,350,644	2,306,133	2,280,158	3,274,537	3,113,883	3,262,995	3,499,585	3,950,880	4,328,575	4,090,034	3,453,633	3,655,993	4,278,502	4,434,176	4,634,558	5,408,420	4,444,164	5,731,201	5,725,575
Number angler days	359,436	407,757	469,915	544,264	556,949	588,087	502,146	532,190	496,286	523,063	536,175	515,152	557,154	516,255	495,805	#	#	#	#	#	#	•	•
Number anglers	§	§	§	§	§	§	§	§	§	§	§	§	§	637,498	593,916	595,866	643,155	695,373	688,103	857,000	780,102	849,654	802,811
Number angler hours	§	§	§	§	§	§	§	§	§	§	§	§	§	2,710,890.2	2,861,660.2	2,903,001.6	3,193,687.7	3,478,965.9	3,456,217.5	4,193,764.5	3,880,630.4	4,294,901.6	4,034,065.9
Numberboatsstatewide	343	430	464	596	562	593	599	612	556	515	454	382	396	402	384	358	377	373	363	407	397	412	406

• Ocean and San Francisco Bay catch (Sacramento-San Joaquin Delta catches not included until 1964).
† Catch statistics maintained elsewhere until 1960—See Chadwick, 1962.
‡ Fishery closed 1917–1953.
§ Not available until 1960. Must be estimated 1947–1959.
# This statistic discontinued in 1962.

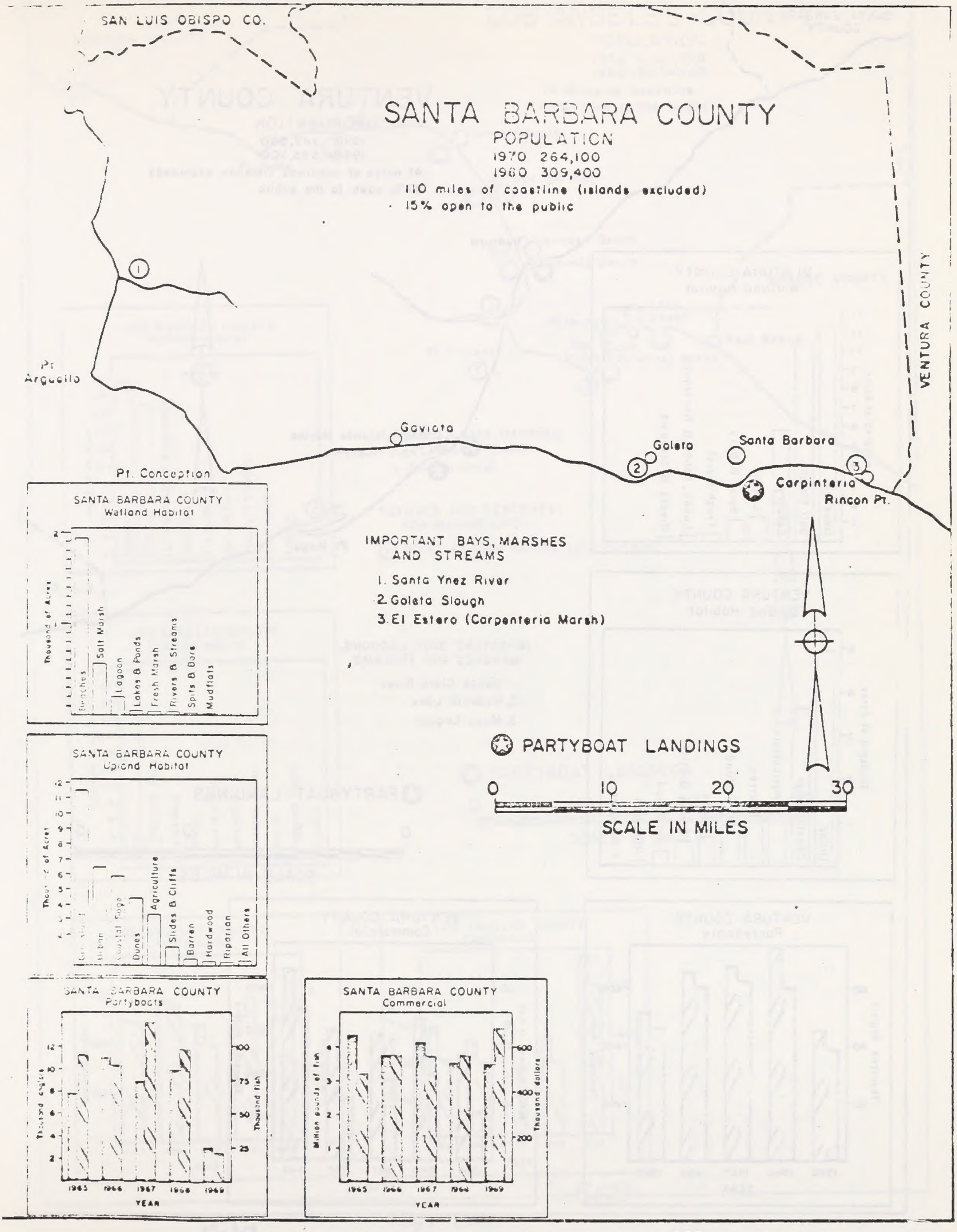


Fig. 15-1 Calif. Fish & Game 1973

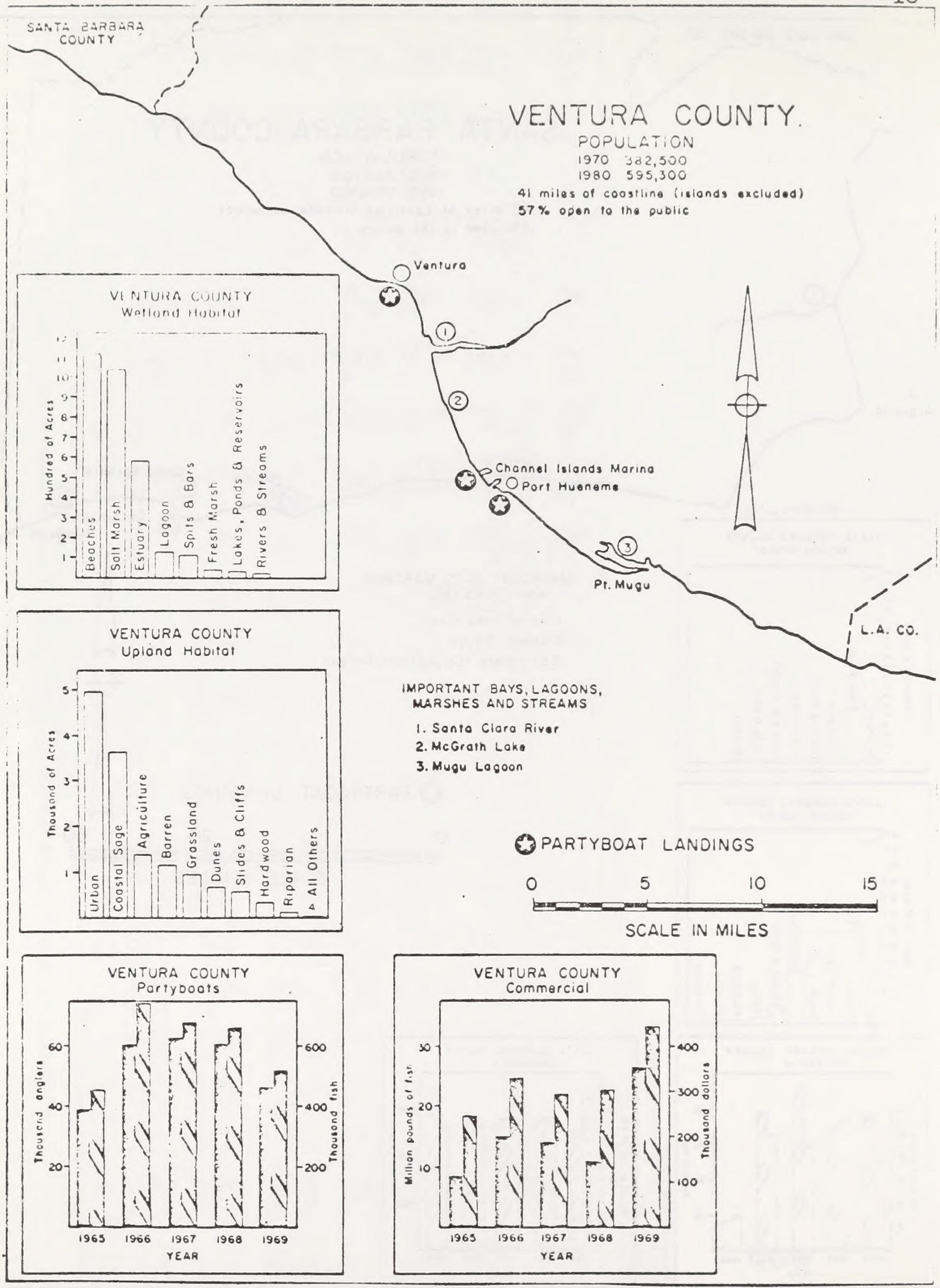

SANTA BARBARA COUNTY
VENTURA COUNTY
POPULATION
1970 382,500
1980 595,300
41 miles of coastline (islands excluded)
57% open to the public
Ventura
1
2
Channel Islands Marina
Port Hueneme
3
Pt. Mugu
L.A. CO.
IMPORTANT BAYS, LAGOONS, MARSHES AND STREAMS
1. Santa Clara River
2. McGrath Lake
3. Mugu Lagoon
PARTYBOAT LANDINGS
0 5 10 15
SCALE IN MILES
VENTURA COUNTY
Wetland Habitat
Hundred of Acres
Beaches
Salt Marsh
Estuary
Lagoon
Spits & Bars
Fresh Marsh
Lakes, Ponds & Reservoirs
Rivers & Streams
VENTURA COUNTY
Upland Habitat
Thousand of Acres
Urban
Coastal Sage
Agriculture
Barren
Grassland
Dunes
Slides & Cliffs
Hardwood
Riparian
All Others
VENTURA COUNTY
Partyboats
Thousand anglers
Thousand fish
1965 1966 1967 1968 1969
YEAR
VENTURA COUNTY
Commercial
Million pounds of fish
Thousand dollars
1965 1966 1967 1968 1969
YEAR

Fig. 15-2

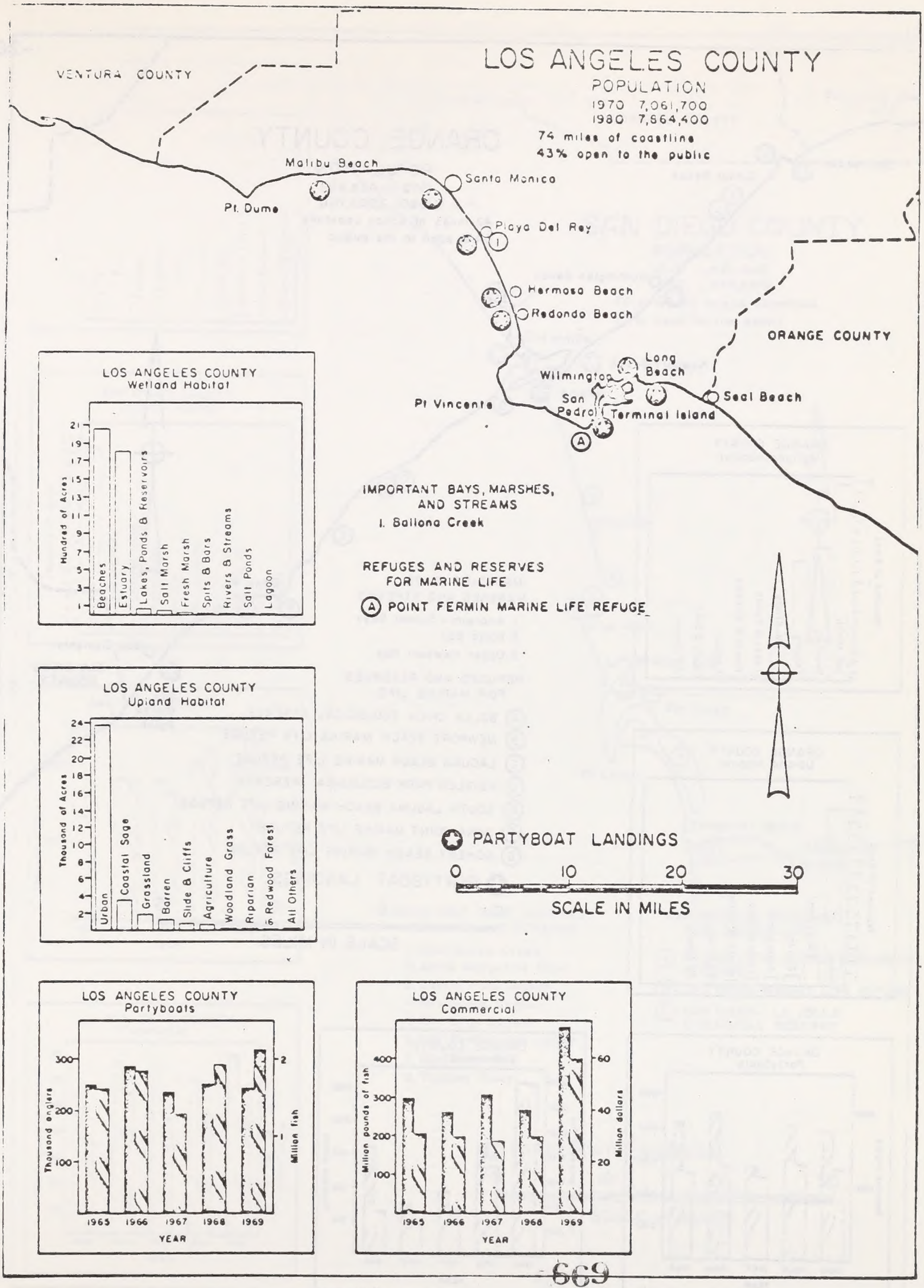

VENTURA COUNTY
LOS ANGELES COUNTY
POPULATION
1970 7,061,700
1980 7,864,400
74 miles of coastline
43% open to the public
Malibu Beach
Pt. Dume
Santa Monica
Playa Del Rey
1
Hermosa Beach
Redondo Beach
ORANGE COUNTY
Long Beach
Wilmington
San Pedro
Terminal Island
Seal Beach
Pt Vincente
A
IMPORTANT BAYS, MARSHES, AND STREAMS
1. Ballona Creek
REFUGES AND RESERVES FOR MARINE LIFE
Ⓐ POINT FERMIN MARINE LIFE REFUGE
PARTYBOAT LANDINGS
0
10
20
30
SCALE IN MILES
LOS ANGELES COUNTY
Wetland Habitat
Hundred of Acres
1
3
5
7
9
11
13
15
17
19
21
Beaches
Estuary
Lakes, Ponds & Reservoirs
Salt Marsh
Fresh Marsh
Spits & Bars
Rivers & Streams
Salt Ponds
Lagoon
LOS ANGELES COUNTY
Upland Habitat
Thousand of Acres
2
4
6
8
10
12
14
16
18
20
22
24
Urban
Coastal Sage
Grassland
Barren
Slide & Cliffs
Agriculture
Woodland Grass
Riparian
Redwood Forest
All Others
LOS ANGELES COUNTY
Partyboats
Thousand anglers
100
200
300
Million fish
1
2
1965
1966
1967
1968
1969
YEAR
LOS ANGELES COUNTY
Commercial
Million pounds of fish
100
200
300
400
Million dollars
20
40
60
1965
1966
1967
1968
1969
YEAR

Fig. 15-3

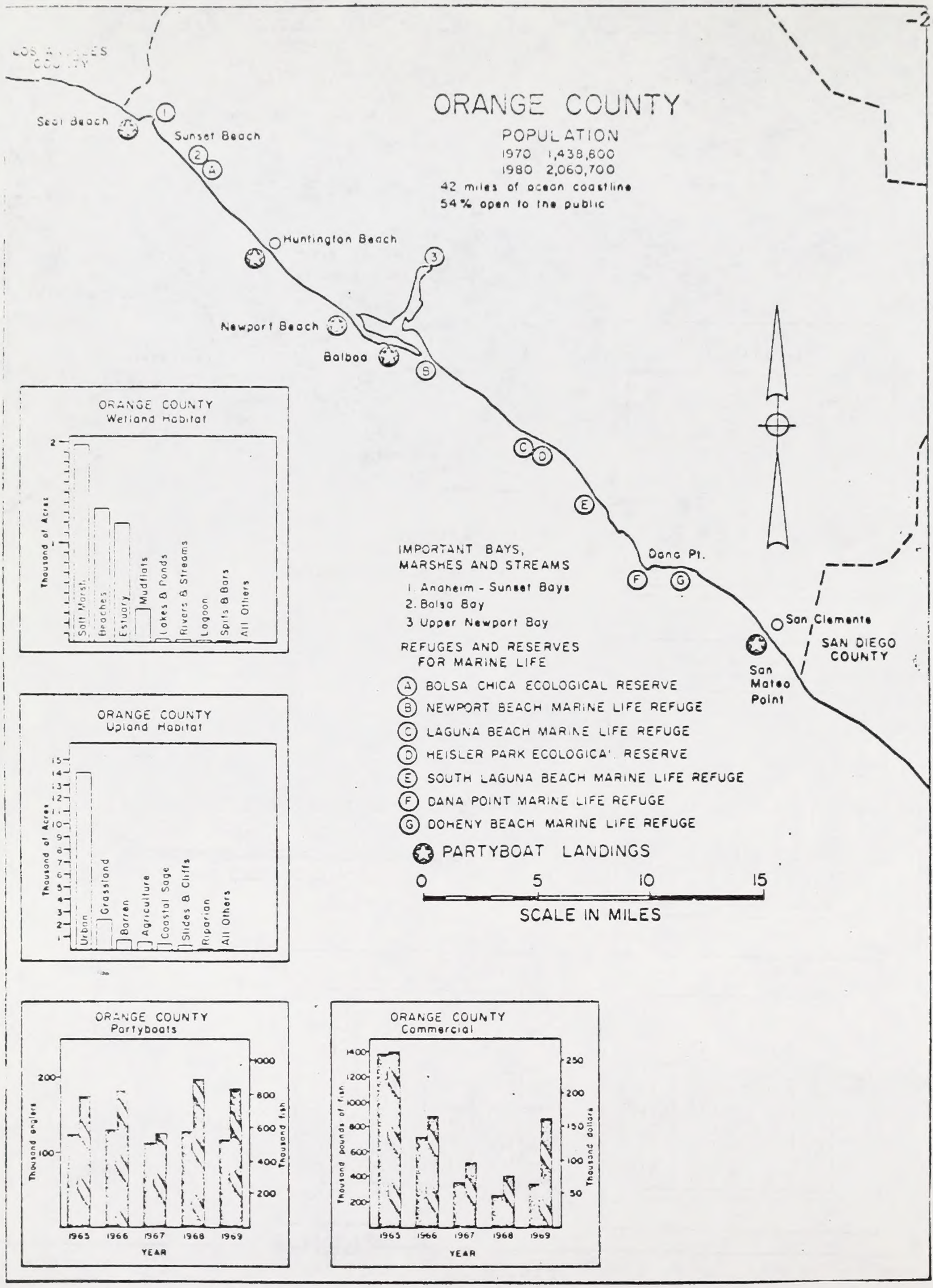

LOS ANGELES COUNTY
ORANGE COUNTY
POPULATION
1970 1,438,600
1980 2,060,700
42 miles of ocean coastline
54% open to the public
Seal Beach
Sunset Beach
Huntington Beach
Newport Beach
Balboa
Dana Pt.
San Clemente
San Mateo Point
SAN DIEGO COUNTY
1
2
3
A
B
C
D
E
F
G
IMPORTANT BAYS, MARSHES AND STREAMS
1. Anaheim - Sunset Bays
2. Bolsa Bay
3 Upper Newport Bay
REFUGES AND RESERVES FOR MARINE LIFE
Ⓐ BOLSA CHICA ECOLOGICAL RESERVE
Ⓑ NEWPORT BEACH MARINE LIFE REFUGE
Ⓒ LAGUNA BEACH MARINE LIFE REFUGE
Ⓓ HEISLER PARK ECOLOGICAL RESERVE
Ⓔ SOUTH LAGUNA BEACH MARINE LIFE REFUGE
Ⓕ DANA POINT MARINE LIFE REFUGE
Ⓖ DOHENY BEACH MARINE LIFE REFUGE
PARTYBOAT LANDINGS
0 5 10 15
SCALE IN MILES
ORANGE COUNTY
Wetland Habitat
Thousand of Acres
2
Salt Marsh
Beaches
Estuary
Mudflats
Lakes & Ponds
Rivers & Streams
Lagoon
Spits & Bars
All Others
ORANGE COUNTY
Upland Habitat
Thousand of Acres
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
Urban
Grassland
Barren
Agriculture
Coastal Sage
Slides & Cliffs
Riparian
All Others
ORANGE COUNTY
Partyboats
Thousand anglers
100 200
Thousand fish
200 400 600 800 1000
1965 1966 1967 1968 1969
YEAR
ORANGE COUNTY
Commercial
Thousand pounds of fish
200 400 600 800 1000 1200 1400
Thousand dollars
50 100 150 200 250
1965 1966 1967 1968 1969
YEAR

Fig. 15-4

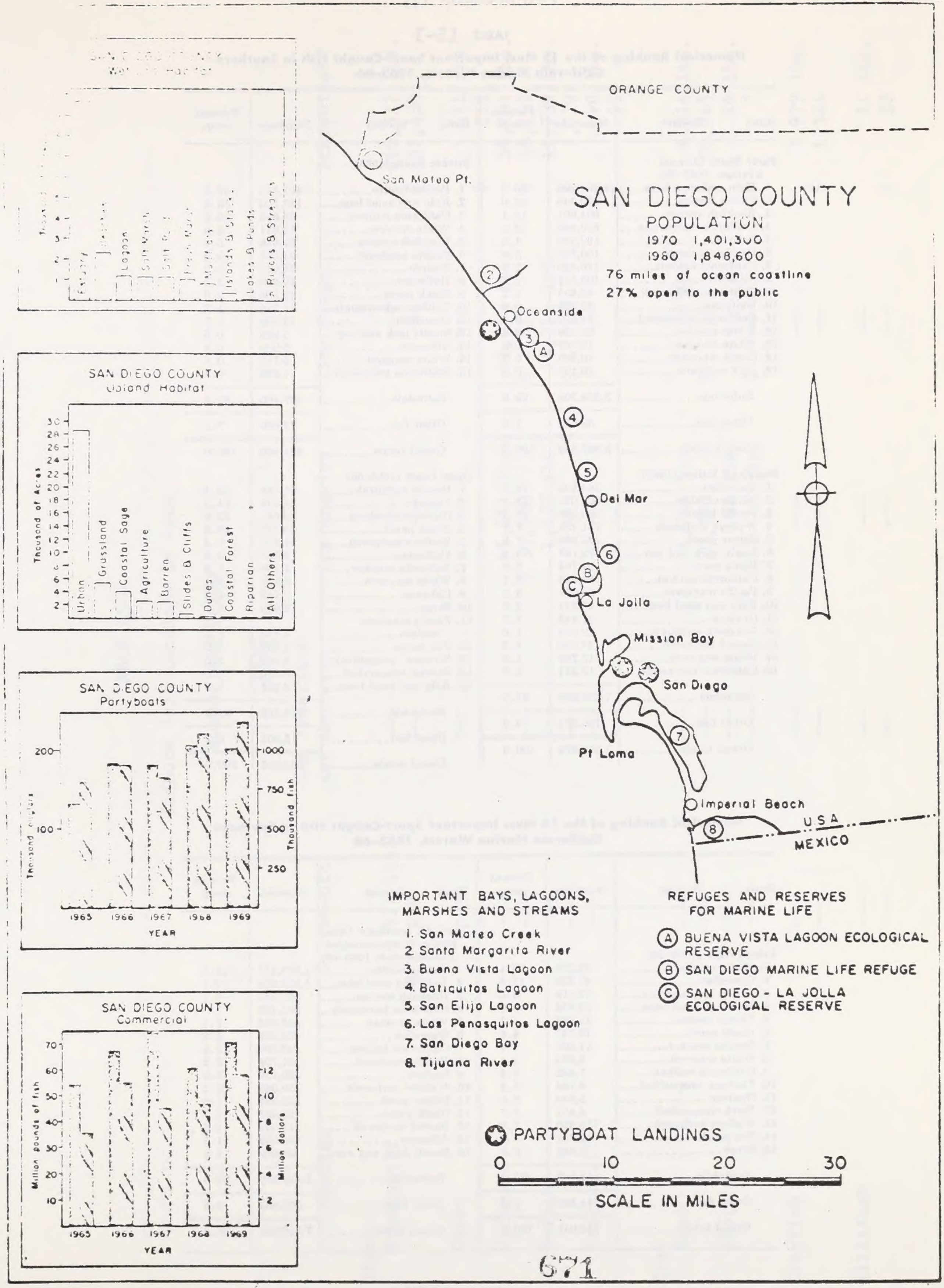

SAN DIEGO COUNTY
Wetland Habitat
Thousand
1
2
3
4
Estuary
Lagoon
Salt Marsh
Salt Pond
Fresh Marsh
Mudflats
Islands & Sloughs
Lakes & Ponds
Rivers & Streams
SAN DIEGO COUNTY
Upland Habitat
Thousand of Acres
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Urban
Grassland
Coastal Sage
Agriculture
Barren
Slides & Cliffs
Dunes
Coastal Forest
Riparian
All Others
SAN DIEGO COUNTY
Partyboats
Thousand anglers
100
200
Thousand fish
250
500
750
1000
1965
1966
1967
1968
1969
YEAR
SAN DIEGO COUNTY
Commercial
Million pounds of fish
10
20
30
40
50
60
70
Million dollars
2
4
6
8
10
12
1965
1966
1967
1968
1969
YEAR
ORANGE COUNTY
San Mateo Pt.
SAN DIEGO COUNTY
POPULATION
1970 1,401,300
1980 1,848,600
76 miles of ocean coastline
27% open to the public
Oceanside
Del Mar
La Jolla
Mission Bay
San Diego
Pt Loma
Imperial Beach
USA
MEXICO
1
2
3
4
5
6
7
8
A
B
C
IMPORTANT BAYS, LAGOONS, MARSHES AND STREAMS
1. San Mateo Creek
2. Santa Margarita River
3. Buena Vista Lagoon
4. Batiquitos Lagoon
5. San Elijo Lagoon
6. Los Penasquitos Lagoon
7. San Diego Bay
8. Tijuana River
REFUGES AND RESERVES FOR MARINE LIFE
A BUENA VISTA LAGOON ECOLOGICAL RESERVE
B SAN DIEGO MARINE LIFE REFUGE
C SAN DIEGO - LA JOLLA ECOLOGICAL RESERVE
PARTYBOAT LANDINGS
0
10
20
30
SCALE IN MILES

Fig. 15-5

TABLE 15-3

Numerical Ranking of the 15 Most Important Sport-Caught Fish in Southern California Marine Waters, 1963–66

Rank Species	Numbers	Percent comp.	Rank Species	Numbers	Percent comp.
Party Boats (Annual Average, 1963-66)			**Private Boats** (1964)		
1. Kelp and sand bass	1,207,996	30.2	1. Pacific bonito	401,575	42.0
2. Pacific bonito	879,335	22.0	2. Kelp and sand bass	132,150	13.8
3. Rockfish species	604,601	15.1	3. California halibut	98,692	10.3
4. California barracuda	530,688	13.3	4. White croaker	84,641	8.8
5. Sculpin	192,369	4.8	5. Rockfish species	51,516	5.4
6. Pacific mackerel	150,739	3.8	6. Pacific mackerel	24,173	2.5
7. California halibut	116,489	2.9	7. Sculpin	21,025	2.2
8. Albacore	103,748	2.6	8. Halfmoon	19,879	2.1
9. California yellowtail	45,834	1.2	9. Black perch	19,558	2.0
10. Halfmoon	35,202	0.9	10. California barracuda	16,235	1.7
11. California sheephead	34,970	0.9	11. Queenfish	15,939	1.7
12. White croaker	23,359	0.6	12. Smelt, jack and top	5,936	0.6
13. White seabass	12,109	0.3	13. Albacore	5,902	0.6
14. Ocean whitefish	10,608	0.3	14. White seaperch	5,713	0.6
15. Jack mackerel	10,161	0.3	15. California yellowtail	4,926	0.5
Subtotals	3,958,208	99.0	Subtotals	907,860	92.5
Other fish	39,631	1.0	Other fish	73,600	7.5
Grand totals	3,997,839	100.0	Grand totals	981,460	100.0
Piers and Jetties (1963)			**Open Coast** (1965-66)		
1. Queenfish	362,892	19.7	1. Barred surfperch	85,743	36.4
2. White croaker	342,002	18.5	2. Opaleye	33,494	14.2
3. Pacific bonito	283,068	15.3	3. California corbina	29,644	12.6
4. Walleye surfperch	141,151	7.7	4. Black perch	25,413	10.8
5. Shiner perch	132,968	7.2	5. Walleye surfperch	12,405	5.3
6. Smelt, jack and top	72,187	3.9	6. Halfmoon	8,563	3.6
7. Black perch	64,764	3.5	7. Yellowfin croaker	4,190	1.8
8. California halibut	56,933	3.1	8. White seaperch	3,212	1.4
9. Pacific mackerel	56,669	3.1	9. Cabezon	2,743	1.2
10. Kelp and sand bass	46,821	2.5	10. Sargo	2,659	1.1
11. Opaleye	31,448	1.7	11. Pacific staghorn sculpin	2,412	1.0
12. Northern anchovy	29,686	1.6	12. Pile perch	2,389	1.0
13. Barred surfperch	23,990	1.3	13. Wrasses, unspecified	2,380	1.0
14. White seaperch	17,769	1.0	14. Sharks, unspecified	2,310	1.0
15. California barracuda	17,351	0.9	15. Kelp and sand bass	2,231	1.0
Subtotals	1,678,699	91.0	Subtotals	219,788	93.3
Other fish	166,271	9.0	Other fish	15,905	6.7
Grand totals	1,844,970	100.0	Grand totals	235,693	100.0

Numerical Ranking of the 15 Most Important Sport-Caught Fish in Southern California Marine Waters, 1963–66

Rank Species	Numbers	Percent comp.	Rank Species	Numbers	Percent comp.
Inland Bays (1965-66)			**Total All Southern California** (Representative Annual Catch, 1963-66)		
1. White croaker	93,278	35.1	1. Pacific bonito	1,579,171	21.6
2. Queenfish	47,228	17.8	2. Kelp and sand bass	1,390,958	19.1
3. Smelt, jack and top	17,518	6.6	3. Rockfish species	661,220	9.1
4. Kelp and sand bass	15,656	6.0	4. California barracuda	565,166	7.7
5. Pacific bonito	15,193	5.7	5. White croaker	545,012	7.5
6. Black perch	12,747	4.8	6. Queenfish	426,592	5.8
7. Spotfin croaker	11,695	4.4	7. California halibut	280,369	3.8
8. White seaperch	8,983	3.4	8. Pacific mackerel	231,708	3.2
9. California halibut	7,422	2.8	9. Sculpin	220,129	3.0
10. Turbots, unspecified	6,154	2.3	10. Walleye surfperch	159,089	2.2
11. Opaleye	5,344	2.0	11. Shiner perch	133,386	1.8
12. Perch unspecified	4,451	1.7	12. Black perch	122,482	1.7
13. Walleye surfperch	3,895	1.5	13. Barred surfperch	113,599	1.6
14. Pile perch	2,351	0.9	14. Albacore	109,650	1.5
15. Sargo	2,243	0.8	15. Smelt, Jack and top	96,809	1.3
Subtotals	254,158	95.5	Subtotals	6,635,340	90.6
Other fish	11,883	4.5	Other fish	690,663	9.4
Grand totals	266,041	100.0	Grand totals	7,326,003	100.0

TABLE 15-4

Inshore Bait Landings by Area

Pounds and Value

1972

Species	Sacramento	San Francisco and Monterey	Los Angeles	San Diego	Statewide**
Clam					
Freshwater	640,527 lbs.	---	---	---	640,527 lbs.
	$ 67,430	---	---	---	$ 67,430
Gaper	---	---	---	---	471 lbs.
	---	---	---	---	$ 118
Jacknife	---	---	45,551 lbs.	12,653 lbs.	58,204 lbs.
	---	---	$ 30,580	$ 7,612	$ 38,192
Purple	---	---	1,423 lbs	14,316 lbs.	15,739 lbs.
	---	---	$ 810	$ 6,919	$ 7,729
Unclassified	---	---	---	---	90 lbs.
	---	---	---	---	$ 52
Crab					
Sand	---	---	6,786 lbs.	28 lbs.	6,814 lbs.
	---	---	$ 20,770	$ 175	$ 20,945
Shore	---	---	25 lbs.	---	26 lbs.
	---	---	5 lbs.	$ ---	$ 7
Crayfish	---	---	---	---	3,979 lbs.
	---	---	---	---	$ 1,544
Killifish	---	---	---	---	11 lbs.
	---	---	---	---	$ 32

TABLE 15-4 (Cont.)

Species	Sacramento	San Francisco and Monterey	Los Angeles	San Diego	Statewide
Mudsucker, longjaw	---	---	---	223 lbs.	6,511 lbs.
	---	---	---	$ 88	$ 5,830
Mussel (bay and rock)	---	---	101,114 lbs.	14,428 lbs.	115,799 lbs.
	---	---	$ 17,121	$ 2,024	$ 19,171
Sculpin, staghorn	702 lbs.	185 lbs.	---	---	887 lbs.
	$ 2,297	$ 695	---	---	$ 2,992
Shrimp					
Bay	71,402 lbs.	1,665 lbs.	---	---	73,067 lbs.
	$113,433	$ 2,423	---	---	$115,856
Brine	---	---	---	---	300,065 lbs.
	---	---	---	---	$174,934
Ghost	---	---	15,672 lbs.	5,882 lbs.	21,554 lbs.
	---	---	$ 35,718	$11,222	$ 46,940
Red	---	---	1,103 lbs.	---	1,103 lbs.
	---	---	$ 1,103	---	$ 1,103
TOTAL	712,631 lbs.	1,850 lbs.	171,674 lbs.	47,530 lbs.	1,244,847 lbs.
	$183,160	$ 3,118	$106,107	$28,040	$502,875

*Oliphant Unpublished file 1974.
**Some figures are reported statewide only to avoid revealing the business of an individual in an area.

Resources Agency of California
Department of Fish and Game
Table 15-5 - REPORT OF THE SOUTHERN CALIFORNIA PARTYBOAT FLEET
Statewide - 1972
(Oliphant unpublished files, 1974)

SPECIES	S.Diego Mission Bay	Dana Harbor O'side	Hunt.B. Newport Balboa	S.Pedro Long Beach	Malibu Red.Bch. S.Monica	Sta.Barb. Port Hueneme
Rockfish	148,029	51,037	118,602	321,284	726,580	568,951
Kelp & sand bass	100,140	125,698	121,743	255,106	116,854	123,140
Pacific bonito	90,385	83,616	71,712	87,246	79,122	6,525
Pacific mackerel	114,803	49,762	44,773	27,189	8,700	614
Halfmoon	8,748	1,149	12,994	62,896	40,118	33,732
Salmon	12	8	6	7	12	57
Lingcod	4,073	131	128	277	157	7,809
Albacore	75,544	550	100	31	...	125
Sculpin	6,566	13,237	16,908	19,610	7,635	1,921
Yellowtail	52,976	724	189	2,036	2,382	724
White croaker	68	21,883	12,999	1,792	30	250
Barracuda	24,473	4,311	941	4,549	3,420	549
Sheephead	6,778	2,738	3,209	8,527	1,805	10,482
Striped bass	...	...	...	...	...	...
Ocean whitefish	5,602	1,209	1,823	6,109	1,879	7,993
Misc. flatfish	1,221	536	166	1,929	2,167	3,656
Sablefish	10	98	1,080	662	9,160	407
Cabezon	421	317	437	258	374	1,722
Calif. halibut	1,604	2,066	571	1,307	944	1,360
Jack mackerel	2,186	48	433	403	625	88
Croaker	15	3,957	2	1	...	21

Table 15-5 (Cont.)

	S.Diego Mission Bay	Dana Harbor O'side	Hunt.B. Newport Balboa	S.Pedro Long Beach	Malibu Red.Bch. S.Monica	Sta.Barb. Port Hueneme
White seabass	1,849	252	323	874	333	205
Bluefin tuna	1,436	17	3	1	...	1
Sturgeon	...	...	...	...	...	...
All others	19,825	3,721	5,262	2,202	1,761	1,107
TOTAL FISH	666,764	367,065	414,454	804,296	1,004,058	771,529
TOTAL ANGLERS	166,000	64,227	50,913	92,366	111,115	68,052
TOTAL BOATS	100	16	24	59	13	35

Note: Smaller ports not listed separately are included in neighboring areas.

APPENDIX 16

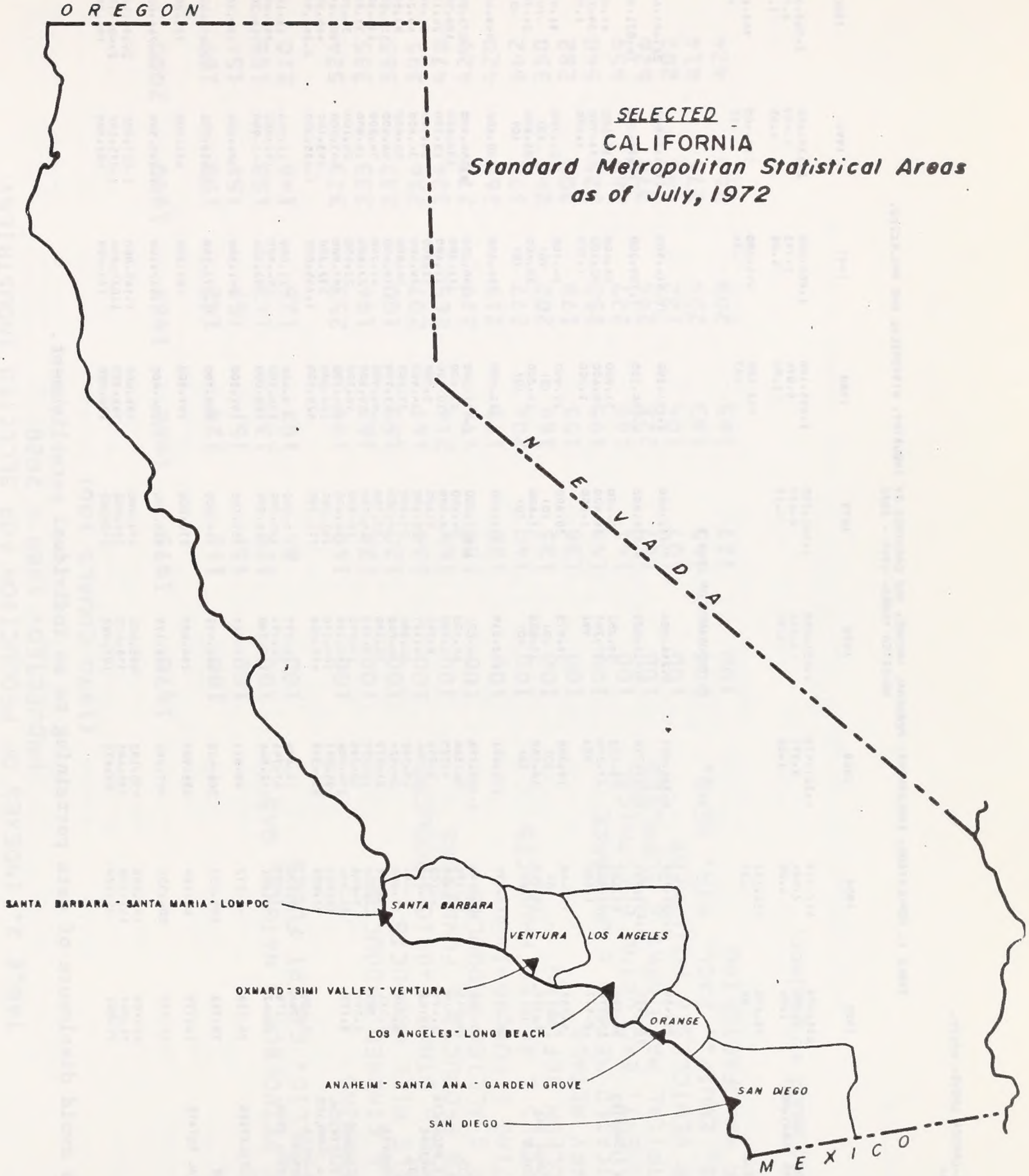
POPULATION, EMPLOYMENT, PERSONAL INCOME AND EARNINGS BY INDUSTRY: HISTORICAL AND PROJECTED 1950 - 2020; INDEXES OF PRODUCTION FOR SELECTED INDUSTRIES, PROJECTED 1980 - 2020; BUREAU ON ECONOMIC ANALYSIS (BEA) CODE NUMBERS 308, 409, 445, 477, 481

Table 1. Population, Employment, Personal Income and Earnings by Industry, Historical and Projected, 1950 - 2020.

Table 2. Indexes of Production for Selected Industries, Projected, 1980 - 2020.

Bureau of Economic Analysis (BEA) Code Numbers 308, 409, 445, 477, 481.

Source: U. S. Department of Commerce, July 1972.



SELECTED

CALIFORNIA

Standard Metropolitan Statistical Areas as of July, 1972

OREGON
NEVADA
MEXICO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
SAN DIEGO
SANTA BARBARA - SANTA MARIA - LOMPOC
OXNARD - SIMI VALLEY - VENTURA
LOS ANGELES - LONG BEACH
ANAHEIM - SANTA ANA - GARDEN GROVE
SAN DIEGO

SMSA - ANAHEIM-SANTA ANA-GARDEN GROVE, CALIF.
(BEA CODE NUMBER - 308)

TABLE 1. POPULATION, EMPLOYMENT, PERSONAL INCOME, AND EARNINGS BY INDUSTRY, HISTORICAL AND PROJECTED,
SELECTED YEARS, 1950 - 2020

	1950	1959	1968	1970	1975	1980	1985	1990	2000	2020
POPULATION, MIDYEAR	218,078	692,719	1,321,428	1,431,099	1,542,200	1,695,100	1,900,400	2,130,600	2,568,100	3,639,200
PER CAPITA INCOME (1967$)*	2,180	2,924	3,577	3,666	4,657	5,074	5,743	6,499	8,724	14,947
PER CAPITA INCOME RELATIVE (US=1.00)	1.06	1.20	1.08	1.06	1.13	1.06	1.06	1.05	1.05	1.05
TOTAL EMPLOYMENT	78,670	254,131				563,100	645,300	739,400	963,100	1,461,300
EMPLOYMENT/POPULATION RATIO	.36	.37				.33	.34	.35	.38	.40
IN THOUSANDS OF 1967 $										
TOTAL PERSONAL INCOME *	475,485	2,025,449	4,726,965	5,246,924	7,182,600	8,601,200	10,914,900	13,847,900	22,403,600	54,396,300
TOTAL EARNINGS	384,375	1,255,865	3,159,710	3,422,629	4,625,800	6,050,100	7,705,300	9,813,100	16,021,900	38,945,300
AGRICULTURE, FORESTRY & FISHERIES	58,090	58,483	28,122	28,252	30,400	31,800	33,400	35,100	41,400	71,700
AGRICULTURE	55,274	56,901	27,199	27,261	29,400	30,600	32,100	33,700	39,700	69,200
FORESTRY & FISHERIES	2,817	1,582	923	991	1,000	1,200	1,300	1,400	1,700	2,400
MINING	6,083	11,449	18,398	18,973	20,800	22,900	24,700	26,700	31,900	44,800
METAL	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
CRUDE PETROLEUM & NATURAL GAS	5,367	10,043	16,169	15,688	17,800	19,200	20,400	21,600	24,700	30,900
NONMETALLIC, EXCEPT FUELS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
CONTRACT CONSTRUCTION	36,687	153,939	215,051	242,319	311,200	385,800	481,300	600,600	949,400	2,206,200
MANUFACTURING	43,700	309,640	1,208,778	1,164,021	1,671,000	2,157,100	2,690,200	3,354,900	5,275,000	12,150,000
FOOD & KINDRED PRODUCTS	14,315	36,176	56,364	60,303	74,600	93,400	111,300	132,600	188,500	354,500
TEXTILE MILL PRODUCTS	814	1,457	4,725	6,702	8,000	10,100	12,600	15,700	24,100	52,500
APPAREL & OTHER FABRIC PRODUCTS	2,477	4,105	5,251	6,361	7,800	9,700	11,800	14,500	21,900	47,800
LUMBER PRODUCTS & FURNITURE	3,182	10,010	14,704	16,127	20,600	24,900	29,400	34,800	49,200	93,100
PAPER & ALLIED PRODUCTS		7,380	19,582	21,364	27,900	35,800	44,600	55,600	87,500	202,900
PRINTING & PUBLISHING	5,775	17,608	34,924	38,068	49,000	63,700	79,400	98,900	155,200	355,600
CHEMICALS & ALLIED PRODUCTS	1,711	13,658	21,672	25,480	32,700	46,900	61,200	79,800	134,900	344,900
PETROLEUM REFINING	883	2,209	12,257	10,963	15,800	19,300	22,800	26,900	37,800	70,200
PRIMARY METALS	1,377	5,066	12,285	13,803	16,800	18,500	21,600	25,100	34,200	59,800
FABRICATED METALS & ORDNANCE	3,155	55,376	174,406	160,169	228,400	304,800	387,900	493,700	804,800	1,961,600
MACHINERY, EXCLUDING ELECTRICAL		18,865	95,071	104,136	143,900	184,000	232,300	293,100	469,500	1,107,800
ELECTRICAL MACHINERY & SUPPLIES		97,098	536,345	447,088	717,300	929,500	1,155,000	1,435,300	2,243,700	5,124,400
TOTAL MACHINERY (1950 ONLY)	3,439									
MOTOR VEHICLES & EQUIPMENT	251	1,352	10,884	10,737	9,600	9,400	11,000	12,800	18,100	35,500
TRANS. EQUIP., EXCL. MTR. VEHS.	279	7,079	67,741	78,451	100,700	126,500	154,900	189,500	286,600	609,100
OTHER MANUFACTURING	6,042	32,201	142,566	164,268	216,000	280,000	353,300	445,900	718,300	1,729,600
TRANS., COMM. & PUBLIC UTILITIES	25,158	48,772	99,811	121,763	151,100	191,300	241,500	304,900	489,700	1,160,900
WHOLESALE & RETAIL TRADE	79,752	209,353	506,410	588,492	764,000	999,700	1,272,100	1,618,700	2,645,500	6,419,300
FINANCE, INSURANCE & REAL ESTATE	16,770	62,184	155,907	194,830	230,000	287,800	361,200	453,400	723,200	1,708,800
SERVICES	51,730	204,557	497,082	578,175	789,400	1,084,900	1,432,100	1,890,500	3,266,000	8,560,400
GOVERNMENT	66,406	197,488	430,152	485,803	653,400	888,400	1,165,000	1,527,900	2,599,300	6,622,700
CIVILIAN GOVERNMENT	41,504	151,558	330,681	378,415	539,000	768,300	1,027,800	1,375,100	2,404,100	6,302,700
ARMED FORCES	24,902	35,929	99,471	107,388	110,300	120,000	135,400	152,700	195,200	320,000

(D) deleted to avoid disclosure of data pertaining to an individual establishment.

SMSA - ANAHEIM - SANTA ANA - GARDEN GROVE, CALIF.
(BEA CODE NUMBER - 308)

TABLE 2. INDEXES OF PRODUCTION FOR SELECTED INDUSTRIES, PROJECTED, 1980 - 2020

(1970 EQUALS 100)

	1970	1975	1980	1985	1990	2000	2020
MINING	100	116	129	142	155	187	260
METAL	100	(S)	(S)	(S)	(S)	(S)	(S)
CRUDE PETROLEUM & NATURAL GAS	100	119	131	143	155	185	249
NONMETALLIC, EXCEPT FUELS	100	84	107	126	148	210	406
MANUFACTURING	100	149	199	253	323	524	1218
FOOD & KINDRED PRODUCTS	100	128	162	194	233	335	636
TEXTILE MILL PRODUCTS	100	120	153	190	237	365	791
APPAREL & OTHER FABRIC PRODUCTS	100	134	167	207	256	395	883
LUMBER PRODUCTS & FURNITURE	100	169	216	265	324	478	948
PAPER & ALLIED PRODUCTS	100	137	176	219	273	429	995
PRINTING & PUBLISHING	100	132	172	215	268	420	961
CHEMICALS & ALLIED PRODUCTS	100	140	206	277	372	662	1846
PETROLEUM REFINING	100	135	168	202	243	350	671
PRIMARY METALS	100	138	153	178	207	282	493
FABRICATED METALS & ORDNANCE	100	144	195	252	325	540	1024
MACHINERY, EXCLUDING ELECTRICAL	100	141	180	227	286	459	1082
ELECTRICAL MACHINERY & SUPPLIES	100	167	228	294	379	626	1522
MOTOR VEHICLES & EQUIPMENT	100	107	104	122	143	202	394
TRANS. EQUIP., EXCL. MTR. VEHS.	100	145	183	224	274	414	879
OTHER MANUFACTURING	100	127	165	208	263	424	1020

(S) too small to project.

SMSA - LOS ANGELES-LONG BEACH, CALIF.
(BEA CODE NUMBER - 409)

TABLE 1. POPULATION, EMPLOYMENT, PERSONAL INCOME, AND EARNINGS BY INDUSTRY, HISTORICAL AND PROJECTED,
SELECTED YEARS, 1950 - 2020

	1950	1959	1968	1970	1975	1980	1985	1990	2000	2020
POPULATION, MIDYEAR	4,187,289	5,942,640	6,928,006	7,029,379	7,884,900	8,717,800	9,631,900	10,641,800	12,589,800	17,456,200
PER CAPITA INCOME (1967$)*	2,677	3,288	4,272	4,403	5,205	5,991	6,699	7,490	9,897	16,420
PER CAPITA INCOME RELATIVE (US=1.00)	1.30	1.35	1.29	1.27	1.27	1.26	1.24	1.21	1.19	1.15
TOTAL EMPLOYMENT	1,629,267	2,406,763				3,843,300	4,163,800	4,511,100	5,412,600	7,376,300
EMPLOYMENT/POPULATION RATIO	.39	.40				.44	.43	.42	.43	.42
				IN THOUSANDS OF 1967 $						
TOTAL PERSONAL INCOME *	11,208,794	19,537,315	29,598,518	30,948,842	41,037,900	52,228,100	64,527,900	79,708,400	124,598,400	286,631,600
TOTAL EARNINGS	9,204,189	16,534,387	24,752,924	25,317,855	33,781,300	42,463,900	52,151,200	64,047,400	99,024,200	223,654,800
AGRICULTURE, FORESTRY & FISHERIES	118,980	95,827	107,203	117,245	114,900	117,700	123,900	130,500	154,400	265,200
AGRICULTURE	100,331	86,881	100,697	110,296	107,000	108,600	113,900	119,500	140,700	245,500
FORESTRY & FISHERIES	18,649	8,946	6,507	6,949	7,700	9,000	9,900	11,000	13,700	20,700
MINING	111,685	101,170	119,029	114,770	132,500	147,000	157,700	169,200	199,400	271,800
METAL	4,063	753	62	65	(S)	(S)	(S)	(S)	(S)	(S)
CRUDE PETROLEUM & NATURAL GAS	92,994	80,080	100,964	96,907	110,600	120,800	128,100	135,900	155,300	194,300
NONMETALLIC, EXCEPT FUELS	14,628	20,337	18,003	17,799	21,700	25,900	29,200	32,900	43,500	76,700
CONTRACT CONSTRUCTION	768,312	1,060,503	1,161,562	1,250,738	1,609,900	2,017,800	2,495,900	3,087,100	4,847,200	11,173,300
MANUFACTURING	2,510,235	5,783,065	7,908,409	7,364,653	10,026,900	12,061,700	14,326,600	17,016,600	24,866,300	52,097,800
FOOD & KINDRED PRODUCTS	272,485	353,477	453,169	439,820	557,700	656,500	751,200	859,500	1,144,100	1,966,800
TEXTILE MILL PRODUCTS	22,168	21,456	46,409	48,560	66,500	80,300	94,000	110,100	154,000	294,400
APPAREL & OTHER FABRIC PRODUCTS	169,710	201,462	277,043	279,436	356,500	428,500	499,500	582,200	808,900	1,530,400
LUMBER PRODUCTS & FURNITURE	140,993	190,837	256,820	258,260	307,100	342,700	380,100	421,500	538,000	888,900
PAPER & ALLIED PRODUCTS	41,709	89,469	136,108	141,269	177,900	215,100	256,300	305,500	447,200	938,600
PRINTING & PUBLISHING	135,537	245,661	351,005	374,534	482,900	597,800	729,600	890,600	1,351,300	2,951,500
CHEMICALS & ALLIED PRODUCTS	77,387	138,769	259,176	266,290	358,600	450,400	552,800	678,400	1,043,800	2,357,400
PETROLEUM REFINING	111,707	163,460	210,575	209,628	249,500	283,000	319,200	360,100	469,400	790,600
PRIMARY METALS	138,735	179,398	267,012	248,061	313,000	353,900	396,400	444,200	568,500	912,300
FABRICATED METALS & ORDNANCE	218,913	749,177	1,094,362	882,798	1,362,800	1,686,300	2,060,200	2,517,100	3,850,700	8,609,200
MACHINERY, EXCLUDING ELECTRICAL		424,611	742,307	770,812	992,900	1,191,600	1,421,200	1,694,900	2,513,800	5,397,500
ELECTRICAL MACHINERY & SUPPLIES		744,456	1,149,681	1,090,461	1,476,300	1,771,800	2,157,700	2,627,700	4,084,700	9,512,400
TOTAL MACHINERY (1950 ONLY)	310,126									
MOTOR VEHICLES & EQUIPMENT	95,842	145,986	317,862	282,045	316,700	326,500	382,200	447,400	631,900	1,235,600
TRANS. EQUIP., EXCL. MTR. VEHS.	540,375	1,643,021	1,635,205	1,324,306	2,008,600	2,449,800	2,824,700	3,257,100	4,487,300	8,426,300
OTHER MANUFACTURING	234,548	491,826	711,676	748,372	990,200	1,226,900	1,494,200	1,819,700	2,772,000	6,285,300
TRANS., COMM. & PUBLIC UTILITIES	631,341	1,011,069	1,593,595	1,734,063	2,164,600	2,642,700	3,196,700	3,866,800	5,835,500	12,807,300
WHOLESALE & RETAIL TRADE	1,979,178	3,117,550	4,369,694	4,578,528	6,014,200	7,618,700	9,372,800	11,530,700	17,922,400	40,644,300
FINANCE, INSURANCE & REAL ESTATE	599,463	979,396	1,548,563	1,562,442	2,043,400	2,551,200	3,094,900	3,754,400	5,662,800	12,384,200
SERVICES	1,581,631	2,739,563	4,649,826	4,997,975	6,753,200	8,773,200	11,019,600	13,841,000	22,160,900	52,370,500
GOVERNMENT	903,364	1,646,244	3,295,044	3,597,442	4,888,800	6,533,500	8,341,800	10,650,600	17,375,000	41,639,000
CIVILIAN GOVERNMENT	828,212	1,505,487	2,991,138	3,323,643	4,531,900	6,168,700	7,926,900	10,186,300	16,781,800	40,666,500
ARMED FORCES	75,152	140,756	303,906	273,799	344,500	364,800	411,500	464,200	593,200	972,500

(S) too small to project.

SMSA - LOS ANGELES-LONG BEACH, CALIF.
(BEA CODE NUMBER - 409)

TABLE 2. INDEXES OF PRODUCTION FOR SELECTED INDUSTRIES, PROJECTED, 1980 - 2020

(1970 EQUALS 100)

	1970	1975	1980	1985	1990	2000	2020
MINING	100	119	133	146	159	192	263
METAL	100	(S)	(S)	(S)	(S)	(S)	(S)
CRUDE PETROLEUM & NATURAL GAS	100	119	133	145	158	188	253
NONMETALLIC, EXCEPT FUELS	100	116	140	158	178	236	415
MANUFACTURING	100	142	173	208	251	377	792
FOOD & KINDRED PRODUCTS	100	131	156	179	207	279	484
TEXTILE MILL PRODUCTS	100	138	167	196	229	320	613
APPAREL & OTHER FABRIC PRODUCTS	100	138	168	198	234	332	643
LUMBER PRODUCTS & FURNITURE	100	157	186	213	244	326	565
PAPER & ALLIED PRODUCTS	100	132	160	190	227	332	696
PRINTING & PUBLISHING	100	132	164	201	245	371	811
CHEMICALS & ALLIED PRODUCTS	100	147	189	239	302	490	1207
PETROLEUM REFINING	100	111	128	148	170	227	395
PRIMARY METALS	100	143	162	182	203	260	418
FABRICATED METALS & ORDNANCE	100	156	196	242	300	469	815
MACHINERY, EXCLUDING ELECTRICAL	100	131	157	188	224	332	712
ELECTRICAL MACHINERY & SUPPLIES	100	141	178	225	285	467	1158
MOTOR VEHICLES & EQUIPMENT	100	133	138	161	189	266	521
TRANS. EQUIP., EXCL. MTR. VEHS.	100	172	209	241	278	384	720
OTHER MANUFACTURING	100	128	159	193	236	359	813

(S) too small to project.

SMSA - OXNARD - SIMI VALLEY - VENTURA, CALIF.
(BEA CODE NUMBER - 445)

TABLE 2. INDEXES OF PRODUCTION FOR SELECTED INDUSTRIES, PROJECTED, 1980 - 2020

(1970 EQUALS 100)

	1970	1975	1980	1985	1990	2000	2020
MINING	100	109	122	134	147	177	246
CRUDE PETROLEUM & NATURAL GAS	100	108	121	131	143	171	229
NONMETALLIC, EXCEPT FUELS	100	133	155	182	214	302	585
MANUFACTURING	100	153	213	272	348	565	1332
FOOD & KINDRED PRODUCTS	100	137	190	234	288	429	853
APPAREL & OTHER FABRIC PRODUCTS	100	169	266	352	465	777	1832
LUMBER PRODUCTS & FURNITURE	100	180	248	316	401	622	1303
PAPER & ALLIED PRODUCTS	100	48	59	80	107	185	480
PRINTING & PUBLISHING	100	137	185	238	306	504	1228
CHEMICALS & ALLIED PRODUCTS	100	155	234	317	430	775	2190
PETROLEUM REFINING	100	132	154	185	223	322	617
PRIMARY METALS	100	147	170	203	243	343	627
FABRICATED METALS & ORDNANCE	100	161	209	267	342	562	1047
MACHINERY, EXCLUDING ELECTRICAL	100	149	229	314	430	766	2027
ELECTRICAL MACHINERY & SUPPLIES	100	173	246	322	422	713	1793
MOTOR VEHICLES & EQUIPMENT	100	(S)	(S)	(S)	(S)	(S)	(S)
TRANS. EQUIP., EXCL. MTR. VEHS.	100	217	305	372	454	683	1445
OTHER MANUFACTURING	100	113	156	205	268	455	1170

(S) too small to project.

SMSA - SAN DIEGO. CALIF.
BEA CODE NUMBER - 477

TABLE 1. POPULATION. EMPLOYMENT. PERSONAL INCOME. AND EARNINGS BY INDUSTRY. HISTORICAL AND PROJECTED. SELECTED YEARS. 1950 - 2020

	1950	1959	1968	1970	1975	1980	1985	1990	2000	2020
POPULATION. MIDYEAR	561.583	1.016.567	1.285.843	1.357.550	1.474.600	1.596.100	1.741.900	1.901.000	2.186.100	2.854.800
PER CAPITA INCOME (1967$)*	2.307	2.575	3.494	3.539	4.118	4.672	5.275	5.955	7.972	13.705
PER CAPITA INCOME RELATIVE (US=1.00)	1.12	1.05	1.06	1.02	1.00	.98	.97	.97	.96	.96
TOTAL EMPLOYMENT	224.255	418.247				654.500	700.900	750.600	873.700	1.140.300
EMPLOYMENT/POPULATION RATIO	.40	.41				.41	.40	.39	.40	.40
				IN THOUSANDS OF 1967 $						
TOTAL PERSONAL INCOME *	1.295.818	2.618.109	4.493.330	4.804.470	6.072.100	7.457.500	9.188.300	11.320.600	17.427.100	39.154.900
TOTAL EARNINGS	1.053.764	2.155.863	3.568.523	3.775.644	4.855.100	5.954.300	7.292.400	8.931.200	13.603.600	30.058.200
AGRICULTURE. FORESTRY & FISHERIES	47.492	39.187	51.893	52.686	55.500	56.700	58.700	60.700	71.900	122.800
AGRICULTURE	27.572	32.404	46.734	47.095	49.300	49.500	50.800	52.200	61.400	107.200
FORESTRY & FISHERIES	19.920	6.784	5.159	5.591	6.100	7.100	7.800	8.500	10.500	15.600
MINING	1.010	4.110	4.848	5.936	7.000	8.500	9.900	11.500	16.100	31.100
METAL	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
CRUDE PETROLEUM & NATURAL GAS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
NONMETALLIC. EXCEPT FUELS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
CONTRACT CONSTRUCTION	80.065	191.673	199.457	236.452	290.300	350.300	429.000	525.300	799.400	1.755.500
MANUFACTURING	131.854	410.718	591.316	611.867	814.600	1.008.400	1.222.400	1.481.700	2.239.300	4.944.600
FOOD & KINDRED PRODUCTS	46.398	55.394	31.480	31.827	38.300	44.700	51.800	60.000	82.300	149.500
TEXTILE MILL PRODUCTS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
APPAREL & OTHER FABRIC PRODUCTS	3.542	9.580	13.777	13.541	18.200	22.600	27.000	32.300	47.100	96.900
LUMBER PRODUCTS & FURNITURE	4.931	10.851	9.153	9.562	11.300	13.200	15.300	17.600	24.000	44.500
PAPER & ALLIED PRODUCTS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
PRINTING & PUBLISHING	11.526	27.989	31.168	36.292	42.900	52.300	64.100	78.600	120.400	269.200
CHEMICALS & ALLIED PRODUCTS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
PETROLEUM REFINING	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
PRIMARY METALS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
FABRICATED METALS & ORDNANCE	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
MACHINERY. EXCLUDING ELECTRICAL		2.137	30.596	44.132	47.400	60.400	76.000	95.800	154.600	377.600
ELECTRICAL MACHINERY & SUPPLIES		39.189	65.330	72.185	115.900	156.300	204.300	267.100	458.300	1.233.700
TOTAL MACHINERY (1950 ONLY)	3.208									
MOTOR VEHICLES & EQUIPMENT	97	685	23.762	22.927	7.100	2.700	3.500	4.400	7.300	18.300
TRANS. EQUIP.. EXCL. MTR. VEHS.	56.146	221.490	251.288	247.126	349.000	444.600	526.400	623.300	899.500	1.825.100
OTHER MANUFACTURING	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
TRANS.. COMM. & PUBLIC UTILITIES	35.900	89.615	152.792	181.946	218.900	268.700	333.500	413.900	650.700	1.529.600
WHOLESALE & RETAIL TRADE	184.459	318.513	471.224	512.716	659.700	828.500	1.026.700	1.272.500	1.984.800	4.557.500
FINANCE. INSURANCE & REAL ESTATE	37.546	93.799	144.965	160.340	198.800	247.000	304.300	374.900	576.400	1.293.000
SERVICES	122.433	273.525	492.275	580.219	733.700	943.100	1.197.500	1.520.400	2.460.900	5.910.100
GOVERNMENT	413.003	734.731	1.459.755	1.433.488	1.873.100	2.242.800	2.708.000	3.269.800	4.803.600	9.913.600
CIVILIAN GOVERNMENT	165.369	330.473	651.016	720.357	939.100	1.229.000	1.549.900	1.954.500	3.094.700	7.040.800
ARMED FORCES	247.635	404.258	808.739	713.131	925.000	1.013.700	1.154.700	1.315.200	1.708.900	2.872.700

(D) deleted to avoid disclosure of data pertaining to an individual establishment.

SMSA - OXNARD-SIMI VALLEY-VENTURA, CALIF.
(BEA CODE NUMBER - 445)

TABLE 1. POPULATION, EMPLOYMENT, PERSONAL INCOME, AND EARNINGS BY INDUSTRY, HISTORICAL AND PROJECTED, SELECTED YEARS, 1950 - 2020

	1950	1959	1968	1970	1975	1980	1985	1990	2000	2020
POPULATION, MIDYEAR	115.630	195.268	352.573	378.835	418.800	464.500	510.500	561.000	654.000	883.900
PER CAPITA INCOME (1967$)*	2.205	2.630	2.662	2.672	3.274	3.899	4.491	5.173	7.187	12.815
PER CAPITA INCOME RELATIVE (US=1.00)	1.07	1.08	.81	.77	.80	.82	.83	.86	.87	.90
TOTAL EMPLOYMENT	43.274	74.756				139.200	155.200	173.000	216.200	311.200
EMPLOYMENT/POPULATION RATIO	.37	.38				.30	.30	.31	.33	.35
IN THOUSANDS OF 1967 $										
TOTAL PERSONAL INCOME *	254.984	515.357	938.706	1.012.290	1.371.200	1.811.100	2.292.700	2.902.400	4.700.400	11.328.500
TOTAL EARNINGS	192.268	404.421	740.362	771.368	1.058.000	1.378.500	1.743.400	2.205.000	3.566.500	8.555.600
AGRICULTURE, FORESTRY & FISHERIES	51.034	66.073	88.033	74.760	93.600	101.500	106.500	111.700	131.600	229.500
AGRICULTURE	50.740	65.907	87.835	74.620	93.300	101.100	106.000	111.200	130.900	228.500
FORESTRY & FISHERIES	294	166	198	141	(S)	(S)	(S)	(S)	(S)	(S)
MINING	4.907	19.387	18.111	18.957	20.300	22.500	24.300	26.200	31.300	44.000
CRUDE PETROLEUM & NATURAL GAS	4.892	19.098	15.928	16.697	17.200	18.800	20.000	21.200	24.200	30.300
NONMETALLIC, EXCEPT FUELS	15	289	2.183	2.261	3.100	3.600	4.200	5.000	7.000	13.700
CONTRACT CONSTRUCTION	14.342	38.537	33.973	48.753	59.300	69.200	89.600	116.000	194.400	488.500
MANUFACTURING	9.137	54.219	126.063	116.649	176.300	239.100	300.700	378.100	599.200	1.378.500
FOOD & KINDRED PRODUCTS	2.761	3.870	10.166	10.288	13.600	18.700	22.800	27.900	41.200	81.000
APPAREL & OTHER FABRIC PRODUCTS	7	329	2.073	2.171	3.400	5.200	6.800	8.900	16.600	33.800
LUMBER PRODUCTS & FURNITURE	65	321	901	1.078	1.400	1.900	2.300	2.800	4.200	8.500
PAPER & ALLIED PRODUCTS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
PRINTING & PUBLISHING	1.112	1.822	5.223	5.960	7.900	10.700	13.700	17.700	29.200	71.100
CHEMICALS & ALLIED PRODUCTS	4	1.895	3.332	3.580	5.100	7.400	9.800	12.900	22.100	57.400
PETROLEUM REFINING	(D)	(D)	1.836	1.790	2.500	2.900	3.400	4.000	5.600	10.500
PRIMARY METALS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
FABRICATED METALS & ORDNANCE	1.973	1.909	7.119	6.091	9.600	12.400	15.600	19.700	31.800	76.200
MACHINERY, EXCLUDING ELECTRICAL		775	4.190	5.677	8.300	12.700	17.500	24.000	42.700	113.100
ELECTRICAL MACHINERY & SUPPLIES		12	27.895	22.727	37.700	50.900	64.300	81.100	129.900	306.800
TOTAL MACHINERY (1950 ONLY)	226									
MOTOR VEHICLES & EQUIPMENT			4.117	2.916	(S)	(S)	(S)	(S)	(S)	(S)
TRANS. EQUIP., EXCL. MTR. VEHS.	1.877	40.630	45.422	31.807	61,000	85.600	104.500	127.500	192.000	406.000
OTHER MANUFACTURING	323	1.958	10.158	14.313	16.600	23.000	30.200	39.500	67.200	172.900
TRANS., COMM. & PUBLIC UTILITIES	6.700	11.748	30.812	33.501	45.500	59.400	75.200	95.300	154.900	378.500
WHOLESALE & RETAIL TRADE	32.852	58.548	102.869	121.959	153.300	198.800	251.500	318.200	515.600	1.236.800
FINANCE, INSURANCE & REAL ESTATE	4.475	10.547	23.104	25.042	35.300	49.300	64.200	83.600	140.500	354.300
SERVICES	18.190	39.283	83.190	93.999	135.000	191.700	256.000	341.800	601.200	1.613.700
GOVERNMENT	50.631	106.078	234.208	237.747	335.400	446.600	572.400	733.700	1.197.500	2.831.500
CIVILIAN GOVERNMENT	40.250	88.111	183.797	206.899	280.400	385.500	502.800	655.900	1.098.100	2.668.680
ARMED FORCES	10.382	17.767	50.411	30.848	53.900	61.100	68.900	77.700	99.300	162.900

(D) deleted to avoid disclosure of data pertaining to an individual establishment.

(S) too small to project.

SMSA - SAN DIEGO, CALIF.
(BEA CODE NUMBER - 477)

TABLE 2. INDEXES OF PRODUCTION FOR SELECTED INDUSTRIES, PROJECTED, 1980 - 2020

(1970 EQUALS 100)

	1970	1975	1980	1985	1990	2000	2020
MINING	100	109	133	155	180	251	476
METAL	100	(S)	(S)	(S)	(S)	(S)	(S)
CRUDE PETROLEUM & NATURAL GAS	100	(S)	(S)	(S)	(S)	(S)	(S)
NONMETALLIC, EXCEPT FUELS	100	115	141	165	193	272	530
MANUFACTURING	100	139	176	217	269	419	946
FOOD & KINDRED PRODUCTS	100	124	147	171	200	277	509
TEXTILE MILL PRODUCTS	100	(S)	(S)	(S)	(S)	(S)	(S)
APPAREL & OTHER FABRIC PRODUCTS	100	146	183	222	268	400	840
LUMBER PRODUCTS & FURNITURE	100	156	194	232	276	394	764
PAPER & ALLIED PRODUCTS	100	135	174	223	285	456	1117
PRINTING & PUBLISHING	100	121	148	182	223	342	764
CHEMICALS & ALLIED PRODUCTS	100	117	137	158	182	255	471
PETROLEUM REFINING	100	114	137	162	191	274	523
PRIMARY METALS	100	155	168	175	182	213	307
FABRICATED METALS & ORDNANCE	100	138	168	204	249	375	611
MACHINERY, EXCLUDING ELECTRICAL	100	109	139	175	221	356	870
ELECTRICAL MACHINERY & SUPPLIES	100	168	237	322	437	791	2270
MOTOR VEHICLES & EQUIPMENT	100	37	14	18	23	38	95
TRANS. EQUIP., EXCL. MTR. VEHS.	100	160	204	241	286	412	836
OTHER MANUFACTURING	100	114	140	169	204	306	654

(S) too small to project.

SMSA - SANTA BARBARA-SANTA MARIA-LOMPOC, CALIF.
(BEA CODE NUMBER - 481)

TABLE 1. POPULATION, EMPLOYMENT, PERSONAL INCOME, AND EARNINGS BY INDUSTRY, HISTORICAL AND PROJECTED, SELECTED YEARS, 1950 - 2020

	1950	1959	1968	1970	1975	1980	1985	1990	2000	2020
POPULATION, MIDYEAR	99.062	166.272	257.049	264.514	293.300	322.200	350.700	381.700	437.200	575.300
PER CAPITA INCOME (1967$)*	2.769	2.939	3.031	3.119	3.695	4.284	4.939	5.694	7.944	14.286
PER CAPITA INCOME RELATIVE (US=1.00)	1.34	1.20	.92	.90	.90	.90	.91	.92	.96	1.00
TOTAL EMPLOYMENT	39.130	67.021				116.000	127.600	140.400	171.600	239.800
EMPLOYMENT/POPULATION RATIO	.40	.40				.36	.36	.37	.39	.42
IN THOUSANDS OF 1967 $										
TOTAL PERSONAL INCOME *	274.296	489.615	779.161	825.092	1.083.800	1.380.600	1.732.100	2.173.400	3.473.900	8.219.800
TOTAL EARNINGS	223.601	389.198	630.431	648.185	890.900	1.156.600	1.457.100	1.835.600	2.954.300	7.045.400
AGRICULTURE, FORESTRY & FISHERIES	48.432	28.171	31.501	26.974	26.000	23.400	21.700	20.200	23.800	41.600
AGRICULTURE	47.762	27.964	31.361	26.827	25.900	23.300	21.600	20.100	23.700	41.300
FORESTRY & FISHERIES	669	207	140	147	(S)	(S)	(S)	(S)	(S)	(S)
MINING	1.978	8.270	8.496	10.256	10.500	10.400	11.200	12.000	14.200	19.400
METAL			154	173	200	300	400	500	800	1.600
COAL			11	9				-		
CRUDE PETROLEUM & NATURAL GAS	(D)	(D)	7.280	9.144	9.000	8.600	9.100	9.700	11.000	13.800
NONMETALLIC, EXCEPT FUELS	(D)	(D)	1.051	930	1.200	1.400	1.600	1.700	2.200	3.800
CONTRACT CONSTRUCTION	13.794	36.669	41.083	39.007	61.500	79.000	100.100	127.000	206.500	502.300
MANUFACTURING	30.543	54.178	89.824	90,802	115.000	135.000	161.000	192.100	281.700	592.300
FOOD & KINDRED PRODUCTS	7.764	15.877	9.628	10,061	10,400	11.500	11.900	12.400	13.800	17.700
TEXTILE MILL PRODUCTS	(D)	(D)		11	(S)	(S)	(S)	(S)	(S)	(S)
APPAREL & OTHER FABRIC PRODUCTS	61	95	162	140	(S)	(S)	(S)	(S)	(S)	(S)
LUMBER PRODUCTS & FURNITURE	1.225	1.396	686	826	(S)	(S)	(S)	(S)	(S)	(S)
PAPER & ALLIED PRODUCTS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
PRINTING & PUBLISHING	2.680	4.190	5.141	6.160	6.700	7.800	9.300	10.900	15.700	31.000
CHEMICALS & ALLIED PRODUCTS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
PETROLEUM REFINING	3.831	2.580	1.389	1.310	1.400	1.500	1.600	1.700	1.900	2.700
PRIMARY METALS	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
FABRICATED METALS & ORDNANCE	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
MACHINERY, EXCLUDING ELECTRICAL		2.157	3.269	3.676	4.200	4.800	5.500	6.300	8.600	16.000
ELECTRICAL MACHINERY & SUPPLIES		15.647	16.287	20.393	20.500	22.800	26.300	30.200	40,900	73.100
TOTAL MACHINERY (1950 ONLY)	414									
MOTOR VEHICLES & EQUIPMENT		182	254	305						
TRANS. EQUIP., EXCL. MTR. VEHS.	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
OTHER MANUFACTURING	13.913	9.463	14.180	14.670	19.800	25.300	31.000	38.000	58.400	131.800
TRANS., COMM. & PUBLIC UTILITIES	9.719	14.943	26.950	27.937	36.800	46.600	57.300	70.600	109.500	249.100
WHOLESALE & RETAIL TRADE	44.439	65.758	102.800	107.653	144.100	188.000	232.500	287.700	448.800	1.019.300
FINANCE, INSURANCE & REAL ESTATE	7.778	16.498	25.736	26.238	36.700	48.500	60.800	76.200	121.700	293.400
SERVICES	38.936	85.549	158.481	173.095	241.200	327.000	423.200	547.700	917.500	2.306.000
GOVERNMENT	27.982	78.161	145.561	146.223	214.400	298.500	387.000	501.800	830.100	2.021.600
CIVILIAN GOVERNMENT	21.042	47.708	94.940	105.085	151.500	215.600	285.600	378.400	652.400	1.680.200
ARMED FORCES	6.940	30.453	50.621	41.138	62.700	82.900	101.100	123.400	177.600	341.300

(D) deleted to avoid disclosure of data pertaining to an individual establishment.

(S) too small to project.

SMSA- SANTA BARBARA - SANTA MARIA - LOMPOC, CALIF.
(BEA CODE NUMBER - 481)

TABLE 2. INDEXES OF PRODUCTION FOR SELECTED INDUSTRIES, PROJECTED, 1980 - 2020

(1970 EQUALS 100)

	1970	1975	1980	1985	1990	2000	2020
MINING	100	104	103	113	124	149	207
METAL	100	(S)	(S)	(S)	(S)	(S)	(S)
CRUDE PETROLEUM & NATURAL GAS	100	103	101	110	119	142	191
NONMETALLIC, EXCEPT FUELS	100	125	150	166	185	238	401
MANUFACTURING	100	126	151	182	219	325	618
FOOD & KINDRED PRODUCTS	100	107	119	125	131	148	191
TEXTILE MILL PRODUCTS	100	(S)	(S)	(S)	(S)	(S)	(S)
APPAREL & OTHER FABRIC PRODUCTS	100	(S)	(S)	(S)	(S)	(S)	(S)
LUMBER PRODUCTS & FURNITURE	100	(S)	(S)	(S)	(S)	(S)	(S)
PAPER & ALLIED PRODUCTS	100	(S)	(S)	(S)	(S)	(S)	(S)
PRINTING & PUBLISHING	100	112	132	156	184	263	519
CHEMICALS & ALLIED PRODUCTS	100	(S)	(S)	(S)	(S)	(S)	(S)
PETROLEUM REFINING	100	105	111	120	130	155	223
PRIMARY METALS	100	109	89	96	104	126	182
FABRICATED METALS & ORDNANCE	100	149	188	235	293	462	816
MACHINERY, EXCLUDING ELECTRICAL	100	118	133	153	176	240	443
ELECTRICAL MACHINERY & SUPPLIES	100	105	123	147	175	250	476
TRANS. EQUIP., EXCL. MTR. VEHS.	100	219	207	261	328	516	1153
OTHER MANUFACTURING	100	131	167	205	251	386	871

(S) too small to project.

APPENDIX 17

MATRIX TABLES

Explanation of Proximity Evaluation Table

The following explanations will assist the reviewer in interpreting the data presented in the matrix tables.

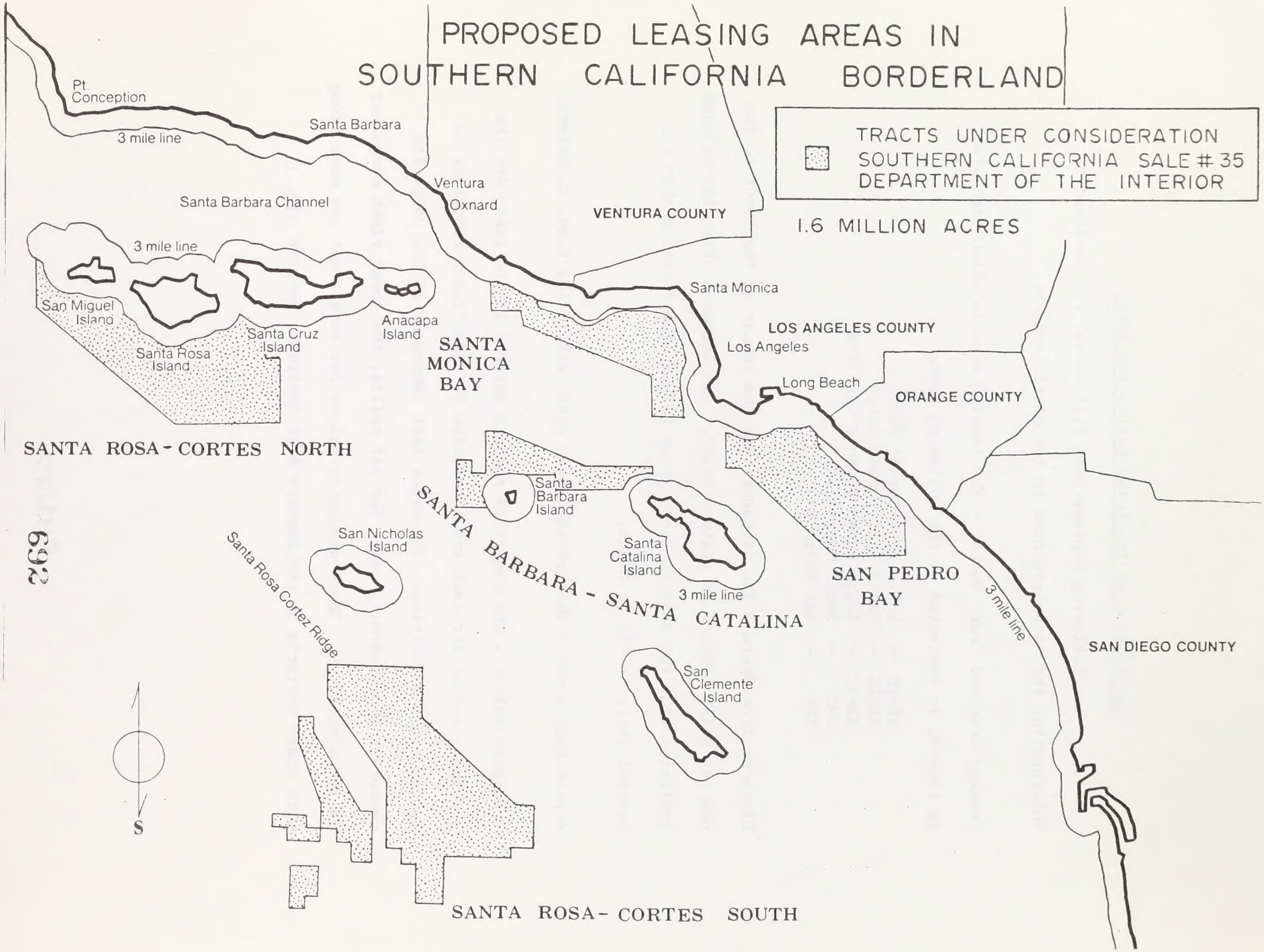
Leasing Area and Tract Number - The leasing area in which each tract is located is indicated by the following code.

SR-CN	Santa Rosa-Cortes North
SR-CS	Santa Rosa-Cortes South
SB-SC	Santa Barbara-Santa Catalina
SMB	Santa Monica Bay
SPB	San Pedro Bay

Distance From Shore - The distance from the center of the tract to the nearest point onshore is statute miles. The letter I after the mileage indicates that the nearest shore is an island, the letter M that the nearest shore is the mainland.

Approximate Depth - The average water depth within the tract in meters.

Proximity Values - The composite numbers entered in the table are the proximity values for each tract relative to significant resources or multiple use activities. The upper left component of the composite number is the proximity value for oil spills, the lower right component is for structures. These proximity values for each tract are used along with other criteria in the Summary Risk Analysis, Section III. L.


PROPOSED LEASING AREAS IN
SOUTHERN CALIFORNIA BORDERLAND
TRACTS UNDER CONSIDERATION
SOUTHERN CALIFORNIA SALE # 35
DEPARTMENT OF THE INTERIOR
1.6 MILLION ACRES
Pt. Conception
3 mile line
Santa Barbara
Ventura
Oxnard
Santa Barbara Channel
VENTURA COUNTY
3 mile line
San Miguel Island
Santa Rosa Island
Santa Cruz Island
Anacapa Island
SANTA MONICA BAY
Santa Monica
LOS ANGELES COUNTY
Los Angeles
Long Beach
ORANGE COUNTY
SANTA ROSA - CORTES NORTH
Santa Barbara Island
SANTA BARBARA - SANTA CATALINA
Santa Catalina Island
3 mile line
SAN PEDRO BAY
3 mile line
SAN DIEGO COUNTY
San Nicholas Island
Santa Rosa Cortez Ridge
San Clemente Island
S
SANTA ROSA - CORTES SOUTH

Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildl. Mgt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archaeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CN 1	3 I	250	1.0/0*	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/0	0.3/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 2	4 I	400	1.0/0	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/0	0.3/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 3	3 I	250	1.0/0	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/0	0.3/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 4	3 I	250	1.0/0	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/0	0.2/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 5	6 I	650	1.0/0	0.9/0	1.0/0	0.9/0	0.9/0	0.9/0	1.0/1	1.0/0	0.3/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 6	4 I	300	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/0	1.0/1	1.0/0	0.3/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 7	4 I	250	1.0/0	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/0	0.2/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 8	3 I	250	1.0/0	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/0	0.1/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 9	3 I	250	1.0/0	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/0	0.1/0	1.0/0	0.0/0	1.0/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlife Mgmt. Areas	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CN 10	3 I	250	1.0* / 0	1.0 / 0	1.0 / 0	0.7 / 0	1.0 / 0	1.0 / 0	1.0 / 1	1.0 / 0	0.1 / 0	1.0 / 0	0.0 / 0	1.0 / 0	1.0 / 1
SR-CN 11	8 I	625	0.7 / 0	0.7 / 0	0.7 / 0	0.7 / 0	0.7 / 0	0.7 / 0	0.8 / 1	0.8 / 0	0.3 / 0	0.8 / 0	0.0 / 0	0.8 / 0	1.0 / 1
SR-CN 12	7 I	500	0.8 / 0	0.8 / 0	0.9 / 0	0.7 / 0	0.7 / 0	0.7 / 0	0.9 / 1	0.9 / 0	0.2 / 0	0.8 / 0	0.0 / 0	0.9 / 0	1.0 / 1
SR-CN 13	6 I	375	0.8 / 0	0.9 / 0	1.0 / 0	0.8 / 0	0.9 / 0	0.7 / 0	1.0 / 1	1.0 / 0	0.2 / 0	1.0 / 0	0.0 / 0	1.0 / 0	1.0 / 1
SR-CN 14	5 I	250	0.9 / 0	1.0 / 0	1.0 / 0	0.7 / 0	0.9 / 0	0.9 / 0	1.0 / 1	1.0 / 0	0.1 / 0	1.0 / 0	0.0 / 0	1.0 / 0	1.0 / 1
SR-CN 15	3 I	250	1.0 / 0	1.0 / 0	1.0 / 0	0.7 / 0	1.0 / 0	1.0 / 0	1.0 / 1	1.0 / 0	0.1 / 0	1.0 / 0	0.0 / 0	1.0 / 0	1.0 / 1
SR-CN 16	4 I	250	1.0 / 0	1.0 / 0	1.0 / 0	0.0 / 0	1.0 / 0	1.0 / 0	1.0 / 1	1.0 / 0	0.3 / 0	1.0 / 1	0.0 / 0	1.0 / 0	1.0 / 1
SR-CN 17	4 I	400	1.0 / 0	1.0 / 0	1.0 / 0	0.0 / 0	1.0 / 0	1.0 / 0	1.0 / 1	1.0 / 0	0.3 / 0	1.0 / 1	0.0 / 0	1.0 / 0	1.0 / 1
SR-CN 18	10 I	625	0.6 / 0	0.7 / 0	0.7 / 0	0.6 / 0	0.7 / 0	0.6 / 0	0.7 / 1	0.7 / 0	0.2 / 0	0.9 / 0	0.0 / 0	0.7 / 0	1.0 / 1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military
SR-CN 19	6 I	500	0.8/0*	0.9/0	1.0/0	0.6/0	0.8/0	0.7/0	1.0/1	0.9/0	0.2/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 20	4 I	500	1.0/0	1.0/0	1.0/0	0.5/0	1.0/0	0.8/0	1.0/1	1.0/0	0.1/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 21	3 I	250	1.0/0	1.0/0	1.0/0	0.4/0	1.0/0	0.8/0	1.0/1	1.0/0	0.0/0	1.0/1	0.0/0	1.0/0	1.0/1
SR-CN 22	3 I	300	1.0/0	1.0/0	1.0/0	0.4/0	1.0/0	0.7/0	1.0/1	1.0/0	0.0/0	1.0/1	0.0/0	1.0/0	1.0/1
SR-CN 23	3 I	250	1.0/0	1.0/0	1.0/0	0.2/0	1.0/0	0.6/0	1.0/1	1.0/0	0.0/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 24	4 I	250	1.0/0	1.0/0	1.0/0	0.2/0	1.0/0	0.4/0	1.0/1	1.0/0	1.0/0	1.0/1	0.0/0	1.0/0	1.0/1
SR-CN 25	5 I	250	1.0/0	1.0/0	1.0/0	0.1/0	1.0/0	1.0/0	1.0/1	1.0/0	0.2/0	1.0/1	0.0/0	1.0/0	1.0/1
SR-CN 26	5 I	250	1.0/0	1.0/0	1.0/0	0.1/0	1.0/0	1.0/0	1.0/1	1.0/0	0.2/0	1.0/1	0.0/0	1.0/0	1.0/1
SR-CN 27	6 I	500	0.9/0	1.0/0	1.0/0	0.0/0	0.9/0	0.8/0	1.0/1	1.0/0	0.2/0	1.0/0	0.0/0	1.0/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlf. Mgnt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CN 28	6 I	250	0.8/0*	0.9/0	1.0/0	0.4/0	0.8/0	0.6/0	1.0/1	0.9/0	0.2/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 29	6 I	400	1.0/0	1.0/0	1.0/0	0.4/0	0.9/0	0.6/0	1.0/1	1.0/0	0.1/0	1.0/1	0.0/0	1.0/0	1.0/1
SR-CN 30	5 I	350	1.0/0	1.0/0	1.0/0	0.3/0	1.0/0	0.6/0	1.0/1	1.0/0	0.0/0	1.0/1	0.0/0	1.0/0	1.0/1
SR-CN 31	5 I	250	1.0/0	1.0/0	1.0/0	0.2/0	1.0/0	0.5/0	1.0/1	1.0/0	0.1/0	1.0/1	0.0/0	1.0/0	1.0/1
SR-CN 32	6 I	250	0.9/0	1.0/0	1.0/0	0.2/0	1.0/0	0.7/0	1.0/1	1.0/0	0.1/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 33	7 I	250	0.8/0	1.0/0	0.9/0	0.1/0	0.9/0	0.7/0	0.9/1	1.0/0	0.2/0	1.0/0	0.0/0	0.9/0	1.0/1
SR-CN 34	8 I	250	0.7/0	0.8/0	0.8/0	0.0/0	0.8/0	0.7/0	0.8/1	1.0/0	0.2/0	1.0/0	0.0/0	0.8/0	1.0/1
SR-CN 35	8 I	300	0.7/0	0.7/0	0.7/0	0.0/0	0.7/0	0.7/0	0.7/1	0.9/0	0.1/0	1.0/0	0.0/0	0.7/0	1.0/1
SR-CN 36	7 I	625	0.7/0	0.8/0	0.9/0	0.3/0	0.7/0	0.5/0	0.9/1	0.8/0	0.1/0	1.0/0	0.0/0	0.8/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlife Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Use
SR-CN 37	6 I	500	0.8*/0	0.8/0	1.0/0	0.2/0	0.8/0	0.5/0	1.0/1	0.9/0	0.1/0	1.0/0	0.0/0	1.0/0	1.0/1
SR-CN 38	8 I	300	0.8/0	0.8/0	0.8/0	0.8/0	0.8/0	0.4/0	0.8/1	0.9/0	0.0/0	1.0/0	0.0/0	0.8/0	1.0/1
SR-CN 39	9 I	250	0.7/0	0.8/0	0.7/0	0.1/0	0.7/0	0.6/0	0.7/1	0.9/0	0.0/0	1.0/0	0.0/0	0.7/0	1.0/1
SR-CN 40	10 I	250	0.7/0	0.7/0	0.7/0	0.1/0	0.7/0	0.6/0	0.7/1	0.8/0	0.1/0	1.0/0	0.0/0	0.7/0	1.0/1
SR-CN 41	11 I	250	0.6/0	0.6/0	0.6/0	0.0/0	0.6/0	0.6/0	0.6/1	0.8/0	0.1/0	1.0/0	0.0/0	0.6/0	1.0/1
SR-CN 42	12 I	250	0.6/0	0.6/0	0.6/0	0.0/0	0.6/0	0.5/0	0.6/1	0.8/0	0.1/0	0.8/0	0.0/0	0.6/0	1.0/1
SR-CN 43	12 I	500	0.6/0	0.6/0	0.6/0	0.0/0	0.6/0	0.5/0	0.6/1	0.7/0	0.0/0	0.7/0	0.0/0	0.6/0	1.0/1
SR-CN 44	11 I	500	0.6/0	0.7/0	0.6/0	0.1/0	0.6/0	0.3/0	0.6/1	0.7/0	0.1/0	0.8/0	0.0/0	0.6/0	1.0/1
SR-CN 45	12 I	250	0.6/0	0.6/0	0.6/0	0.1/0	0.6/0	0.3/0	0.6/1	0.7/0	0.0/0	0.7/0	0.0/0	0.6/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildl. Mgmt. Areas	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CN 46	13 I	250	0.6/0*	0.6/0	0.5/0	0.0/0	0.5/0	0.4/0	0.5/1	0.7/0	0.0/0	0.7/0	0.0/0	0.5/0	1.0/1
SR-CN 47	14 I	250	0.5/0	0.5/0	0.5/0	0.0/0	0.5/0	0.4/0	0.5/1	0.5/0	0.0/0	0.7/0	0.0/0	0.5/0	1.0/1
SR-CN 48	15 I	250	0.4/0	0.4/0	0.4/0	0.0/0	0.4/0	0.4/0	0.4/1	0.6/0	0.0/0	0.7/0	0.0/0	0.4/0	1.0/1
SR-CN 49	15 I	350	0.4/0	0.5/0	0.4/0	0.0/0	0.4/0	0.4/0	0.4/1	0.5/0	0.0/0	0.6/0	0.0/0	0.4/0	1.0/1
SR-CN 50	12 I	600	0.5/0	0.5/0	0.6/0	0.1/0	0.5/0	0.2/0	0.6/1	0.5/0	0.1/0	0.7/0	0.0/0	0.6/0	1.0/1
SR-CN 51	15 I	250	0.4/0	0.5/0	0.4/0	0.0/0	0.4/0	0.2/0	0.4/1	0.5/0	0.1/0	0.6/0	0.0/0	0.4/0	1.0/1
SR-CN 52	16 I	250	0.4/0	0.4/0	0.4/0	0.0/0	0.4/0	0.4/0	0.4/1	0.5/0	0.0/0	0.6/0	0.0/0	0.4/0	1.0/1
SR-CN 53	17 I	250	0.4/0	0.4/0	0.4/0	0.0/0	0.4/0	0.3/0	0.4/1	0.5/0	0.0/0	0.6/0	0.0/0	0.4/0	1.0/1
SR-CN 54	18 I	250	0.3/0	0.4/0	0.3/0	0.0/0	0.3/0	0.3/0	0.3/1	0.4/0	0.0/0	0.5/0	0.0/0	0.3/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlife, Sight. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CN 55	18 I	250	0.3/*0	0.3/0	0.3/0	0.0/0	0.3/0	0.3/0	0.3/1	0.4/0	0.0/0	0.5/0	0.0/0	0.3/0	1.0/1
SR-CN 56	17 I	500	0.3/0	0.4/0	0.4/0	0.0/0	0.3/0	0.1/0	0.4/1	0.4/0	0.1/0	0.4/0	0.0/0	0.4/0	1.0/1
SR-CN 57	18 I	250	0.3/0	0.3/0	0.3/0	0.0/0	0.3/0	0.2/0	0.3/1	0.4/0	0.0/0	0.4/0	0.0/0	0.3/0	1.0/1
SR-CN 58	19 I	250	0.3/0	0.3/0	0.3/0	0.0/0	0.3/0	0.2/0	0.3/1	0.4/0	0.0/0	0.4/0	0.0/0	0.3/0	1.0/1
SR-CN 59	20 I	250	0.2/0	0.3/0	0.3/0	0.0/0	0.3/0	0.2/0	0.3/1	0.4/0	0.0/0	0.4/0	0.0/0	0.3/0	1.0/1
SR-CN 60	21 I	300	0.2/0	0.3/0	0.2/0	0.0/0	0.2/0	0.2/0	0.2/0	0.3/0	0.0/0	0.4/0	0.0/0	0.2/0	1.0/1
SR-CS 61	18 I	500	0.3/0	0.3/0	0.3/0	0.3/0	0.2/0	0.3/0	0.0/0	0.4/0	1.0/1	0.3/0	0.1/0	0.3/0	1.0/1
SR-CS 62	17 I	500	0.4/0	0.3/0	0.4/0	0.4/0	0.2/0	0.4/0	0.0/0	0.4/0	1.0/1	0.4/0	0.2/0	0.4/0	1.0/1
SR-CS 63	17 I	500	0.4/0	0.3/0	0.4/0	0.4/0	0.2/0	0.4/0	0.0/0	0.4/0	1.0/1	0.4/0	0.2/0	0.4/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wldlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CS 64	17 I	500	0.4/0*	0.3/0	0.4/0	0.3/0	0.1/0	0.4/0	0.0/0	0.4/0	1.0/1	0.4/0	0.2/0	0.4/0	1.0/1
SR-CS 65	17 I	500	0.4/0	0.2/0	0.4/0	0.3/0	0.0/0	0.4/0	0.0/0	0.4/0	1.0/1	0.4/0	0.2/0	0.4/0	1.0/1
SR-CS 66	18 I	500	0.3/0	0.2/0	0.3/0	0.3/0	0.0/0	0.3/0	0.0/0	0.4/0	1.0/1	0.3/0	0.2/0	0.3/0	1.0/1
SR-CS 67	21 I	700	0.2/0	0.2/0	0.2/0	0.2/0	0.3/0	0.2/0	0.0/0	0.3/0	1.0/1	0.2/0	0.2/0	0.2/0	1.0/1
SR-CS 68	20 I	500	0.3/0	0.2/0	0.3/0	0.3/0	0.1/0	0.3/0	0.0/0	0.3/0	1.0/1	0.3/0	0.2/0	0.3/0	1.0/1
SR-CS 69	20 I	250	0.3/0	0.2/0	0.3/0	0.3/0	0.0/0	0.3/0	0.0/0	0.3/0	1.0/1	0.3/0	0.2/0	0.3/0	1.0/1
SR-CS 70	20 I	250	0.3/0	0.2/0	0.3/0	0.2/0	0.0/0	0.3/0	0.0/0	0.3/0	1.0/1	0.3/0	0.3/0	0.3/0	1.0/1
SR-CS 71	20 I	250	0.3/0	0.2/0	0.3/0	0.2/0	0.0/0	0.3/0	0.0/0	0.3/0	1.0/1	0.3/0	0.3/0	0.3/0	1.0/1
SR-CS 72	21 I	400	0.2/0	0.1/0	0.2/0	0.2/0	0.0/0	0.2/0	0.0/0	0.3/0	1.0/1	0.2/0	0.3/0	0.2/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
CR-CS 73	23 I	700	0.2/0*	0.1/0	0.2/0	0.2/0	0.0/0	0.2/0	0.0/0	0.2/0	1.0/0	0.2/0	0.3/0	0.2/0	1.0/1
CR-CS 74	23 I	500	0.2/0	0.1/0	0.2/0	0.2/0	0.0/0	0.2/0	0.0/0	0.2/0	1.0/0	0.2/0	0.3/0	0.2/0	1.0/1
CR-CS 75	23 I	250	0.2/0	0.1/0	0.2/0	0.2/0	0.0/0	0.2/0	0.0/0	0.2/0	1.0/0	0.2/0	0.4/0	0.2/0	1.0/1
CR-CS 76	23 I	250	0.2/0	0.1/0	0.2/0	0.1/0	0.0/0	0.2/0	0.0/0	0.2/0	1.0/0	0.2/0	0.4/0	0.2/0	1.0/1
CR-CS 77	24 I	500	0.2/0	0.0/0	0.2/0	0.1/0	0.0/0	0.2/0	0.0/0	0.2/0	1.0/0	0.2/0	0.4/0	0.2/0	1.0/1
CR-CS 78	26 I	750	0.1/0	0.1/0	0.1/0	0.1/0	0.0/0	0.1/0	0.0/0	0.2/0	1.0/0	0.1/0	0.4/0	0.1/0	1.0/1
CR-CS 79	26 I	250	0.1/0	0.0/0	0.1/0	0.1/0	0.0/0	0.1/0	0.0/0	0.2/0	1.0/0	0.1/0	0.5/0	0.1/0	1.0/1
CR-CS 80	26 I	250	0.1/0	0.0/0	0.1/0	0.1/0	0.0/0	0.1/0	0.0/0	0.1/0	1.0/0	0.1/0	0.5/0	0.1/0	1.0/1
CR-CS 81	I 27 I	350	0.1/0	0.0/0	0.1/0	0.1/0	0.0/0	0.1/0	0.0/0	0.1/0	1.0/0	0.1/0	0.5/0	0.1/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildl. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CS 82	27 I	500	0.1*/0	0.0/0	0.1/0	0.0/0	0.0/0	0.1/0	0.0/0	0.1/0	1.0/0	0.1/0	0.5/0	0.1/0	1.0/1
SR-CS 83	27 I	750	0.0/0	0.0/0	0.1/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	1.0/0	0.1/0	0.5/0	0.1/0	1.0/1
SR-CS 84	30 I	750	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.9/0	0.0/0	0.2/0	0.0/0	1.0/1
SR-CS 85	29 I	750	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.9/0	0.0/0	0.6/0	0.0/0	1.0/1
SR-CS 86	29 I	300	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.9/0	0.0/0	0.7/0	0.0/0	1.0/1
SR-CS 87	29 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.9/0	0.0/0	0.7/0	0.0/0	1.0/1
SR-CS 88	30 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.9/0	0.0/0	0.7/0	0.0/0	1.0/1
SR-CS 89	31 I	650	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.9/0	0.0/0	0.7/0	0.0/0	1.0/1
SR-CS 90	33 I	700	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.9/0	0.0/0	0.7/0	0.0/0	1.0/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance From Shore	Approximate Depth (m)	Refuges/Wildlife Mgt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CS 91	32 I	650	0.0/0*	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	0.2/0	0.0/0	1.0/1
SR-CS 92	31 I	650	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	0.3/0	0.0/0	1.0/1
SR-CS 93	32 I	600	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	0.9/0	0.0/0	1.0/1
SR-CS 94	33 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	0.9/0	0.0/0	1.0/1
SR-CS 95	34 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	0.9/0	0.0/0	1.0/0
SR-CS 96	36 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	0.9/0	0.0/0	1.0/0
SR-CS 97	34 I	600	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	0.9/0	0.0/0	1.0/0
SR-CS 98	34 I	475	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	0.3/0	0.0/0	1.0/1
SR-CS 99	34 I	400	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	0.4/0	0.0/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CS 100	35 I	700	0.0/0*	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 101	36 I	600	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 102	36 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	1.0/0	0.0/0	1.0/0
SR-CS 103	37 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	1.0/0	0.0/0	1.0/0
SR-CS 104	38 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	1.0/0	0.0/0	1.0/0
SR-CS 105	36 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 106	33 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.8/0	0.0/0	0.9/0	0.0/0	1.0/1
SR-CS 107	37 I	625	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	0.4/0	0.0/0	1.0/1
SR-CS 108	37 I	275	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	0.5/0	0.0/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance From Shore	Approximate Depth (m)	Refuges/Wldlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CS 109	36 I	650	0.0/0*	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	0.6/0	0.0/0	1.0/1
SR-CS 110	38 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/0	0.0/0	1.0/0
SR-CS 111	39 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/1	0.0/0	1.0/0
SR-CS 112	39 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/1	0.0/0	1.0/0
SR-CS 113	40 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/1	0.0/0	1.0/0
SR-CS 114	40 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 115	37 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 116	34 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	0.9/0	0.0/0	1.0/1
SR-CS 117	31 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.8/0	0.0/0	0.7/0	0.0/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military
SR-CS 118	36 I	600	0.0/0*	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	0.5/0	0.0/0	1.0/0
SR-CS 119	39 I	625	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	0.6/0	0.0/0	1.0/0
SR-CS 120	41 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	1.0/0	0.0/0	1.0/0
SR-CS 121	42 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	1.0/1	0.0/0	1.0/0
SR-CS 122	43 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	1.0/1	0.0/0	1.0/0
SR-CS 123	43 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 124	44 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 125	38 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 126	32 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	1.0/0	0.0/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildl. Mgmt. Areas	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CS 127	33I	700	0.0/0 *	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	0.7/0	0.0/0	1.0/1
SR-CS 128	29I	750	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.9/0	0.0/0	0.6/0	0.0/0	1.0/1
SR-CS 129	45I	625	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	0.2/0	0.0/0	1.0/0
SR-CS 130	44I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	0.3/0	0.0/0	1.0/0
SR-CS 131	43I	675	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	0.5/0	0.0/0	1.0/0
SR-CS 132	42I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	0.6/0	0.0/0	1.0/0
SR-CS 133	42I	725	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	0.8/0	0.0/0	0.9/0
SR-CS 134	44I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	1.0/0	0.0/0	1.0/0
SR-CS 135	45I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	1.0/1	0.0/0	1.0/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildl. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CS 136	45 I	250	0.0/0*	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 137	45 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 138	42 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 139	40 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 140	37 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 141	32 I	725	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	0.7/0	0.0/0	1.0/1
SR-CS 142	30 I	750	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	0.6/0	0.0/0	1.0/1
SR-CS 143	46 I	700	0.0/	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.0/0	0.3/0	0.0/0	0.9/0
SR-CS 144	46 I	725	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.0/0	0.4/0	0.0/0	0.8/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance From Shore	Approximate Depth (m)	Refuges/Wldlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CS 145	45 I	625	0.0/0*	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.0/0	0.6/0	0.0/0	0.7/0
SR-CS 146	45 I	700	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.0/0	0.8/0	0.0/0	0.8/0
SR-CS 147	47 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.0/0	1.0/0	0.0/0	1.0/0
SR-CS 148	46 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 149	49 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 150	46 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 151	43 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 152	41 I	350	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 153	38 I	600	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	1.0/0	0.0/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlife Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SR-CS 154	48 I	750	00/0*	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.1/0	0.0/0	0.8/0	0.0/0	1.0/0
SR-CS 155	51 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 156	50 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 157	48 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/1	0.0/0	1.0/1
SR-CS 158	51 I	750	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	0.8/0	0.0/0	1.0/0
SR-CS 159	52 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 160	50 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.5/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 161	56 I	750	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	0.2/0	0.0/0	0.7/0
SR-CS 162	55 I	725	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.2/0	0.0/0	0.3/0	0.0/0	0.8/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlife Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military
SR-CS 163	53 I	350	0.0/0*	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 164	51 I	250	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	1.0/0	0.0/0	1.0/1
SR-CS 165	59 I	650	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	0.2/0	0.0/0	0.8/0
SR-CS 166	58 I	650	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.3/0	0.0/0	0.3/0	0.0/0	1.0/0
SR-CS 167	55 I	750	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.7/0	0.0/0	0.7/0	0.0/0	1.0/1
SR-CS 168	53 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.8/0	0.0/0	0.7/0	0.0/0	1.0/1
SR-CS 169	62 I	500	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	0.2/0	0.0/0	1.0/0
SR-CS 170	61 I	625	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.4/0	0.0/0	0.2/0	0.0/0	1.0/0
SR-CS 171	65 I	625	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.0/0	0.6/0	0.0/0	0.1/0	0.0/0	1.0/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wldlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SB-CS 172	15 I	650	0.4/0*	0.4/0	0.4/0	0.0/0	0.4/0	0.2/0	0.4/1	0.4/0	0.5/0	1.0/0	0.4/0	0.4/0	1.0/0
SB-CS 173	12 I	300	0.5/0	0.5/0	0.5/0	0.0/0	0.5/0	0.2/0	0.5/1	0.5/0	0.4/0	1.0/1	0.5/0	0.6/0	1.0/0
SB-CS 174	11 I	625	0.5/0	0.5/0	0.5/0	0.0/0	0.5/0	0.1/0	0.5/1	0.5/0	0.5/0	1.0/0	0.5/0	0.5/0	1.0/0
SB-CS 175	9 I	250	0.6/0	0.7/0	0.6/0	0.0/0	0.6/0	0.0/0	0.6/1	0.6/0	0.3/0	1.0/1	0.7/0	0.6/0	1.0/0
SB-CS 176	9 I	400	0.7/0	0.7/0	0.7/0	0.0/0	0.6/0	0.0/0	0.7/1	0.7/0	0.4/0	1.0/0	0.7/0	0.7/0	1.0/0
SB-CS 177	9 I	725	0.6/0	0.7/0	0.6/0	0.0/0	0.6/0	0.1/0	0.6/1	0.6/0	0.4/0	1.0/0	0.7/0	0.6/0	0.8/0
SB-CS 178	10 I	750	0.6/0	0.6/0	0.6/0	0.0/0	0.6/0	0.1/0	0.6/1	0.6/0	0.5/0	0.9/0	0.9/0	0.6/0	0.6/0
SB-CS 179	10 I	375	0.6/0	0.6/0	0.6/0	0.0/0	0.6/0	0.0/0	0.6/1	0.7/0	0.2/0	1.0/0	0.9/0	0.6/0	1.0/1
SB-CS 180	6 I	250	0.8/0	0.8/0	0.8/0	0.0/0	0.8/0	0.0/0	0.8/1	0.8/0	0.3/0	1.0/1	0.9/0	0.8/0	1.0/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance From Shore	Approximate Depth (m)	Refuges/Wildlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SB-SC 181	5 I	250	0.9/*0	0.9/0	0.9/	0.0/0	0.8/0	0.0/0	0.9/1	0.9/0	0.3/0	1.0/0	0.9/0	0.9/0	1.0/0
SB-SC 182	6 I	250	0.8/0	0.9/0	0.8/0	0.0/0	0.8/0	0.0/0	0.8/1	0.8/0	0.3/0	1.0/0	0.9/0	0.8/0	1.0/0
SB-SC 183	8 I	750	0.7/0	0.7/0	0.7/0	0.0/0	0.7/0	0.0/0	0.7/1	0.7/0	0.4/0	1.0/0	0.8/0	0.7/0	1.0/0
SB-SC 184	10 I	750	0.6/0	0.6/0	0.6/0	0.0/0	0.6/0	0.0/0	0.6/1	0.6/0	0.5/0	1.0/0	1.0/0	0.6/0	1.0/0
SB-SC 185	8 I	300	0.7/0	0.7/0	0.7/0	0.0/0	0.7/0	0.0/0	0.7/1	0.8/0	0.1/0	1.0/0	1.0/0	0.7/0	1.0/1
SB-SC 186	3 I	750	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	0.0/0	1.0/1	1.0/0	0.2/0	1.0/1	1.0/0	1.0/0	1.0/0
SB-SC 187	3 I	450	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	0.0/0	1.0/1	1.0/0	0.2/0	1.0/1	1.0/0	1.0/0	1.0/0
SB-SC 188	3 I	250	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	0.0/0	1.0/1	1.0/0	0.3/0	1.0/1	1.0/0	1.0/0	1.0/0
SB-SC 189	6 I	650	0.9/0	0.9/0	1.0/0	0.0/0	0.9/0	0.0/0	0.9/1	0.9/0	0.3/0	1.0/1	1.0/0	1.0/0	1.0/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildl. Mgmt. Areas	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SB-SC 190	9 I	750	0.7/0*	0.7/0	0.7/0	0.0/0	0.7/0	0.0/0	0.7/1	0.7/0	0.4/0	1.0/1	0.8/0	0.7/0	1.0/0
SB-SC 191	11 I	750	0.5/0	0.6/0	0.5/0	0.0/0	0.5/0	0.0/0	0.5/1	0.6/0	0.4/0	1.0/1	0.8/0	0.5/0	1.0/0
SB-SC 192	9 I	750	0.6/0	0.4/0	0.6/0	0.0/0	0.5/0	0.0/0	0.6/1	0.6/	0.5/0	1.0/1	0.8/0	0.6/0	1.0/0
SB-CS 193	9 I	750	0.7/0	0.3/0	0.8/0	0.0/0	0.8/0	0.1/0	0.8/1	0.8/0	0.6/0	1.0/1	1.0/0	0.8/0	1.0/0
SB-CS 194	5 I	750	0.9/0	0.4/0	0.9/0	0.0/0	0.9/0	0.2/0	0.9/1	0.9/0	0.6/0	1.0/1	1.0/0	0.9/0	1.0/0
SB-CS 195	4 I	750	1.0/0	0.5/0	1.0/0	0.0/0	1.0/0	0.2/0	1.0/1	1.0/0	0.7/0	1.0/1	1.0/0	1.0/0	1.0/0
SB-CS 196	7 I	500	0.8/0	0.8/0	0.8/0	0.1/0	0.7/0	0.0/0	0.8/1	0.9/0	0.0/0	1.0/0	1.0/0	0.8/0	1.0/1
SB-CS 197	4 I	375	1.0/0	1.0/0	1.0/0	0.0/0	0.9/0	0.0/0	1.0/1	1.0/0	0.1/0	1.0/0	1.0/1	1.0/0	1.0/1
SB-CS 198	7 I	750	0.7/0	0.8/0	0.7/0	0.0/0	0.7/0	0.0/0	0.7/1	0.8/0	0.3/0	1.0/0	0.9/0	0.7/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlife Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SB-SC 199	10 I	750	0.6/0*	0.6/0	0.6/0	0.0/0	0.6/0	0.0/0	0.6/1	0.6/0	0.3/0	0.8/0	0.7/0	0.6/0	1.0/1
SB-SC 200	8 I	750	0.7/0	0.5/0	0.7/0	0.0/0	0.7/0	0.0/0	0.7/1	0.7/0	0.4/0	1.0/0	1.0/0	0.7/0	1.0/1
SB-SC 201	5 I	750	0.9/0	0.4/0	0.9/0	0.0/0	0.9/0	0.1/0	0.9/1	0.9/0	0.4/0	1.0/0	1.0/0	0.9/0	1.0/1
SB-SC 202	3 I	750	1.0/0	0.5/0	1.0/0	0.0/0	1.0/0	0.1/0	1.0/1	1.0/0	0.5/0	1.0/1	1.0/0	1.0/0	1.0/1
SB-SC 203	7 I	475	0.8/0	0.8/0	0.8/0	0.1/0	0.7/0	0.0/0	0.8/1	0.9/0	0.0/0	1.0/0	1.0/0	0.8/0	1.0/1
SB-SC 204	4 I	250	1.0/0	1.0/0	1.0/0	0.1/0	1.0/0	0.0/0	1.0/1	1.0/0	0.0/0	1.0/0	1.0/1	1.0/0	1.0/1
SB-SC 205	3 I	250	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	0.0/0	1.0/1	1.0/0	0.0/0	1.0/0	1.0/1	1.0/0	1.0/1
SMB 206	4 M	325	1.0/0	1.0/0	1.0/0	0.0/0	0.4/0	1.0/0	1.0/1	1.0/0	1.0/1	1.0/1	0.4/0	1.0/0	1.0/1
SMB 207	3 M	325	1.0/0	1.0/0	1.0/0	0.0/0	0.5/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	0.5/0	1.0/0	1.0/1

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SMB 208	3 M	250	1.0/0 *	1.0/0	1.0/0	0.0/0	0.6/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	0.7/0	1.0/0	1.0/0
SMB 209	6 M	600	0.9/0	0.7/0	0.9/0	0.0/0	0.4/0	0.9/0	0.9/1	1.0/0	1.0/1	1.0/1	0.4/0	0.9/0	1.0/1
SMB 210	5 M	500	1.0/0	0.9/0	1.0/0	0.0/0	0.5/0	1.0/0	1.0/1	1.0/0	1.0/1	1.0/1	0.5/0	1.0/0	1.0/1
SMB 211	4 M	450	1.0/0	1.0/0	1.0/0	0.0/0	0.7/0	1.0/0	1.0/1	1.0/0	1.0/1	1.0/1	0.7/0	1.0/0	1.0/0
SMB 212	4 M	450	1.0/0	1.0/0	1.0/0	0.0/0	0.8/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	0.9/0	1.0/0	0.8/0
SMB 213	3 M	750	0.9/0	1.0/0	0.9/0	0.0/0	0.7/0	0.9/0	0.9/1	1.0/0	1.0/1	1.0/1	0.9/0	0.9/0	0.8/0
SMB 214	5 M	750	0.9/0	1.0/0	1.0/0	0.0/0	0.9/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	0.6/0
SMB 215	7 M	700	1.0/0	0.8/0	1.0/0	0.0/0	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/1	1.0/0	0.5/0
SMB 216	4 M	500	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/1	1.0/0	0.3/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Widlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SmB 217	3 M	500	0.9/0 *	1.0/0	1.0/0	0.0/0	1.0/0	1.0/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/1	1.0/0	0.3/0
SmB 218	5 M	300	0.9/0	1.0/0	1.0/0	0.0/0	0.8/0	1.0/0	1.0/1	1.0/0	0.8/0	1.0/1	1.0/1	1.0/0	0.2/0
SmB 219	5 M	250	0.7/0	1.0/0	1.0/0	0.0/0	0.6/0	1.0/0	1.0/1	1.0/0	0.7/0	1.0/1	1.0/1	1.0/0	0.1/0
SmB 220	5 M	250	0.6/0	1.0/0	1.0/0	0.0/0	0.5/0	1.0/0	1.0/1	1.0/0	0.6/0	1.0/1	1.0/1	1.0/0	0.0/0
SmB 221	4 M	250	0.5/0	1.0/0	1.0/0	0.0/0	0.6/0	1.0/0	1.0/1	1.0/0	0.6/0	1.0/1	1.0/1	1.0/0	0.0/0
SmB 222	5 M	750	0.9/0	0.9/0	0.9/0	0.0/0	0.9/0	0.9/0	0.9/1	1.0/0	1.0/0	1.0/1	1.0/1	0.9/0	0.3/0
SmB 223	7 M	600	0.7/0	0.9/0	0.8/0	0.0/0	0.8/0	0.8/0	0.8/1	0.9/0	1.0/0	1.0/1	1.0/1	0.8/0	0.2/0
SmB 224	8 M	500	0.7/0	0.8/0	0.7/0	0.0/0	0.7/0	0.7/0	0.7/1	0.9/0	1.0/0	1.0/1	1.0/1	0.7/0	0.2/0
SmB 225	8 M	250	0.6/0	0.8/0	0.7/0	0.0/0	0.5/0	0.7/0	0.7/1	0.9/0	0.9/0	1.0/1	1.0/1	0.7/0	0.1/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildl. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SmB 226	6 M	250	0.5*/0	0.8/0	0.8/0	0.0/0	0.6/0	0.8/0	0.8/1	1.0/0	0.7/0	1.0/1	1.0/1	0.8/0	0.0/0
SmB 227	4 M	250	0.4/0	0.9/0	1.0/0	0.0/0	0.7/0	1.0/0	1.0/1	1.0/0	0.7/0	1.0/1	1.0/1	1.0/0	0.0/0
SmB 228	10 M	750	0.6/0	0.6/0	0.6/0	0.0/0	0.6/0	0.6/0	0.6/1	0.7/0	1.0/1	1.0/1	1.0/1	0.6/0	0.2/0
SmB 229	11 M	750	0.5/0	0.6/0	0.6/0	0.0/0	0.6/0	0.6/0	0.6/1	0.7/0	1.0/0	1.0/1	1.0/1	0.6/0	0.1/0
SmB 230	10 M	300	0.5/0	0.6/0	0.6/0	0.0/0	0.5/0	0.6/0	0.6/1	0.7/0	1.0/0	1.0/1	1.0/1	0.6/0	0.1/0
SmB 231	7 M	250	0.4/0	0.7/0	0.8/0	0.0/0	0.7/0	0.7/0	0.8/1	1.0/0	1.0/0	1.0/1	1.0/1	0.8/0	0.1/0
SmB 232	4 M	250	0.3/0	0.9/0	1.0/0	0.0/0	0.8/0	1.0/0	1.0/1	1.0/0	0.8/0	1.0/1	1.0/1	1.0/0	0.1/0
SmB 233	3 M	250	0.3/0	1.0/0	1.0/0	0.0/0	1.0/0	1.0/0	1.0/1	1.0/0	0.8/0	1.0/1	1.0/0	1.0/0	0.1/0
SmB 234	11 M	250	0.4/0	0.6/0	0.5/0	0.0/0	0.6/0	0.5/0	0.5/1	0.7/0	1.0/1	1.0/1	1.0/1	0.5/0	0.2/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wild. & Mgmt. Areas	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SMB 235	8 M	250	0.3/0 *	0.8/0	0.7/0	0.0/0	0.7/0	0.7/0	0.7/1	0.8/0	1.0/0	1.0/1	1.0/1	0.7/0	0.2/0
SMB 236	5 M	250	0.3/0	1.0/0	1.0/0	0.0/0	1.0/0	0.9/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/1	1.0/0	0.2/0
SMB 237	3 M	250	0.2/0	1.0/0	1.0/0	0.0/0	1.0/	1.0/0	1.0/1	1.0/0	0.9/0	1.0/1	1.0/1	1.0/0	0.2/0
SMB 238	7 M	700	0.4/0	0.9/0	0.8/0	0.0/0	0.8/0	0.7/0	0.8/1	0.9/0	1.0/1	1.0/1	1.0/1	0.8/0	0.3/0
SMB 239	4 M	400	0.5/0	1.0/0	1.0/0	0.0/0	1.0/0	0.9/0	1.0/1	1.0/0	1.0/0	1.0/1	1.0/1	1.0/0	0.3/0
SMB 240	7 M	750	0.4/0	0.8/0	0.8/0	0.0/0	0.7/0	0.6/0	0.7/1	0.8/0	1.0/1	1.0/1	1.0/1	0.8/0	0.4/0
SMB 241	5 M	750	0.5/0	1.0/0	1.0/0	0.0/0	1.0/0	0.8/0	1.0/1	1.0/0	1.0/1	1.0/1	1.0/1	1.0/0	0.4/0
SPB 242	4 M	250	1.0/0	0.6/0	1.0/0	0.0/0	0.6/0	1.0/0	1.0/1	1.0/1	1.0/1	1.0/1	1.0/0	1.0/0	0.0/0
SPB 243	6 M	750	1.0/0	0.0/0	1.0/0	0.0/0	1.0/0	0.5/0	1.0/1	1.0/0	1.0/1	1.0/1	1.0/1	1.0/0	0.3/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wldlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SPB 244	5 M	500	1.0/0*	0.0/0	1.0/0	0.0/0	1.0/0	0.6/0	1.0/1	1.0/0	1.0/1	1.0/1	1.0/1	1.0/0	0.2/0
SPB 245	5 M	250	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	0.7/0	1.0/1	1.0/1	1.0/1	1.0/1	1.0/1	1.0/0	0.2/0
SPB 246	7 M	250	1.0/0	0.9/0	0.9/0	0.0/0	0.9/0	0.8/0	0.9/1	1.0/1	1.0/1	1.0/1	1.0/1	0.9/0	0.1/0
SPB 247	6 M	250	0.9/0	0.9/0	1.0/0	0.0/0	0.7/0	1.0/0	1.0/1	1.0/1	1.0/1	1.0/1	1.0/1	1.0/0	0.0/0
SPB 248	4 M	250	1.0/0	0.6/0	1.0/0	0.0/0	0.6/0	1.0/0	1.0/1	1.0/1	1.0/1	1.0/1	1.0/1	1.0/0	0.0/0
SPB 249	4 M	250	0.9/0	0.6/0	1.0/0	0.0/0	0.5/0	1.0/0	1.0/1	1.0/1	1.0/0	1.0/1	1.0/1	1.0/0	0.0/0
SPB 250	8 M	750	0.8/0	0.9/0	0.8/0	0.0/0	0.8/0	0.4/0	0.8/1	1.0/0	1.0/0	1.0/1	1.0/1	0.8/0	0.4/0
SPB 251	7 M	400	0.9/0	0.9/0	0.9/0	0.0/0	0.9/0	0.5/0	0.9/1	1.0/0	1.0/0	1.0/1	1.0/1	0.9/0	0.3/0
SPB 252	7 M	250	0.9/0	0.9/0	0.8/0	0.0/0	0.8/0	0.6/0	0.8/1	1.0/0	1.0/1	1.0/1	1.0/1	0.8/0	0.2/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wldlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SPB 253	9 M	250	0.8/0 *	0.8/0	0.7/0	0.0/0	0.7/0	0.5/0	0.7/1	1.0/1	1.0/1	1.0/1	1.0/1	0.7/0	0.1/0
SPB 254	8 M	250	0.7/0	0.7/0	0.8/0	0.0/0	0.6/0	0.8/0	0.8/1	1.0/1	1.0/1	1.0/1	1.0/1	0.8/0	0.1/0
SPB 255	6 M	250	0.7/0	0.5/0	1.0/0	0.0/0	0.5/0	1.0/0	1.0/1	1.0/1	1.0/1	1.0/1	1.0/1	1.0/0	0.1/0
SPB 256	5 M	250	0.7/0	0.7/0	1.0/0	0.0/0	0.7/0	1.0/0	1.0/1	1.0/1	1.0/0	1.0/1	1.0/1	1.0/0	0.1/0
SPB 257	11 M	750	0.6/0	0.7/0	0.6/0	0.0/0	0.6/0	0.4/0	0.6/1	0.7/0	1.0/0	1.0/1	1.0/1	0.6/0	0.4/0
SPB 258	10 M	700	0.7/0	0.7/0	0.7/0	0.0/0	0.7/0	0.4/0	0.7/1	0.9/0	1.0/0	1.0/1	1.0/1	0.7/0	0.3/0
SPB 259	10 M	250	0.7/0	0.7/0	0.7/0	0.0/0	0.7/0	0.5/0	0.7/1	1.0/0	1.0/1	1.0/1	1.0/1	0.7/0	0.2/0
SPB 260	11 M	250	0.6/0	0.6/0	0.6/0	0.0/0	0.6/0	0.6/0	0.6/1	1.0/0	1.0/1	1.0/1	1.0/1	0.6/0	0.2/0
SPB 261	10 M	250	0.6/0	0.5/0	0.7/0	0.0/0	0.5/0	0.7/0	0.7/1	1.0/0	1.0/1	1.0/0	1.0/1	0.7/0	0.2/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance From Shore	Approximate Depth (m)	Refuges/Wildl. Mgmt. Areas	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SPB 262	8 M	250	0.6/0 *	0.5/0	0.8/0	0.0/0	0.5/0	0.8/0	0.8/1	1.0/0	1.0/0	1.0/1	1.0/1	0.8/0	0.2/0
SPB 263	7 M	250	0.6/0	0.7/0	0.9/0	0.0/0	0.7/0	1.0/0	0.9/1	1.0/1	1.0/0	1.0/1	1.0/1	0.9/0	0.1/0
SPB 264	5 M	250	0.7/0	0.9/0	1.0/0	0.0/0	0.9/0	1.0/0	1.0/1	1.0/0	0.7/0	1.0/1	1.0/1	1.0/0	0.1/0
SPB 265	13 M	750	0.5/0	0.6/0	0.5/0	0.0/0	0.5/0	0.4/0	0.5/1	0.8/0	1.0/0	1.0/1	1.0/1	0.5/0	0.3/0
SPB 266	14 M	500	0.5/0	0.5/0	0.5/0	0.0/0	0.5/0	0.5/0	0.5/1	1.0/0	1.0/0	1.0/1	1.0/1	0.5/0	0.3/0
SPB 267	13 M	250	0.4/0	0.4/0	0.5/0	0.0/0	0.4/0	0.6/0	0.5/1	0.9/0	1.0/0	1.0/1	1.0/1	0.5/0	0.3/0
SPB 268	10 M	400	0.4/0	0.5/0	0.7/0	0.0/0	0.5/0	0.6/	0.7/1	1.0/0	1.0/0	1.0/1	1.0/1	0.7/0	0.2/0
SPB 269	9 M	350	0.6/0	0.6/0	0.7/0	0.0/0	0.6/0	0.7/0	0.7/1	1.0/0	0.8/0	1.0/1	1.0/1	0.7/0	0.2/0
SPB 270	7 M	275	0.7/0	0.8/0	0.9/0	0.0/0	0.8/0	0.9/0	0.9/1	1.0/0	0.7/0	1.0/1	1.0/1	0.9/0	0.2/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlife Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archaeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SPB 271	6 M	300	0.9/0 *	1.0/0	1.0/0	0.0/0	0.9/0	1.0/0	1.0/1	1.0/0	0.5/0	1.0/1	1.0/0	1.0/0	0.2/0
SPB 272	5 M	500	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	1.0/0	1.0/1	1.0/0	0.4/0	1.0/1	1.0/0	1.0/0	0.2/0
SPB 273	15 M	500	0.3/0	0.4/0	0.4/0	0.0/0	0.3/0	0.4/0	0.4/1	0.7/0	0.9/0	1.0/0	1.0/1	0.4/0	0.4/0
SPB 274	13 M	500	0.4/0	0.4/0	0.5/0	0.0/0	0.4/0	0.5/0	0.5/1	0.7/0	0.8/0	1.0/1	1.0/1	0.5/0	0.3/0
SPB 275	11 M	500	0.5/0	0.6/0	0.6/0	0.0/0	0.5/0	0.6/0	0.6/1	0.8/0	0.7/0	1.0/1	1.0/1	0.6/0	0.3/0
SPB 276	10 M	500	0.6/0	0.7/0	0.7/0	0.0/0	0.7/0	0.7/0	0.7/1	0.9/0	0.6/0	1.0/1	1.0/1	0.7/0	0.3/0
SPB 277	9 M	500	0.7/0	0.8/0	0.8/0	0.0/0	0.8/0	0.7/0	0.8/1	0.8/0	0.5/0	1.0/1	1.0/0	0.8/0	0.3/0
SPB 278	7 M	500	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	0.9/0	1.0/1	1.0/0	0.4/0	1.0/1	1.0/0	1.0/0	0.2/0
SPB 279	5 M	500	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	1.0/0	1.0/1	1.0/0	0.3/0	1.0/1	0.7/0	1.0/0	0.2/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wldlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SPB 280	15 M	550	0.4/0*	0.4/0	0.4/0	0.0/0	0.4/0	0.4/0	0.4/1	0.6/0	0.6/0	1.0/0	1.0/1	0.4/0	0.4/0
SPB 281	14 M	500	0.4/0	0.4/0	0.5/0	0.0/0	0.4/0	0.5/0	0.5/1	0.6/0	0.6/0	1.0/1	1.0/1	0.5/0	0.4/0
SPB 282	11 M	500	0.5/0	0.6/0	0.6/0	0.0/0	0.6/0	0.5/0	0.6/1	0.7/0	0.5/0	1.0/1	1.0/1	0.6/0	0.4/0
SPB 283	9 M	500	0.7/0	0.6/0	0.6/0	0.0/0	0.6/0	0.6/0	0.6/1	0.7/0	0.4/0	1.0/1	1.0/0	0.6/0	0.4/0
SPB 284	7 M	500	0.7/0	0.7/0	0.7/0	0.0/0	0.7/0	0.7/0	0.7/1	1.0/0	0.3/0	1.0/1	1.0/0	0.7/0	0.3/0
SPB 285	7 M	500	0.9/0	1.0/0	1.0/0	0.0/0	0.9/0	0.9/0	1.0/1	1.0/0	0.2/0	1.0/1	0.7/0	1.0/0	0.3/0
SPB 286	5 M	500	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	1.0/0	1.0/1	1.0/0	0.2/0	1.0/1	0.6/0	1.0/0	0.3/0
SPB 287	17 M	450	0.4/0	0.3/0	0.4/0	0.0/0	0.4/0	0.4/0	0.4/1	0.5/0	0.4/0	1.0/0	1.0/1	0.4/0	0.5/0
SPB 288	15 M	400	0.4/0	0.4/0	0.4/0	0.0/0	0.4/0	0.4/0	0.4/1	0.5/0	0.4/0	1.0/0	1.0/1	0.4/0	0.5/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

TRACT DATA			NATURAL and CULTURAL RESOURCES								MULTIPLE-USE ACTIVITIES				
Lease Area and Tract Number	Distance from Shore	Approximate Depth (m)	Refuges/Wildlf. Mgmt. Acres	Kelp Beds	Bird Rookeries	Seal Rookeries	Rocky Shore Intertidal Communities	Sandy Beach Intertidal Communities	Aesthetics	Archeology	Shipping	Outdoor Recreation	Commercial Fishing	Sport Fishing	Military Uses
SPB 289	12 M	500	0.5*/0	0.5/0	0.5/0	0.0/0	0.5/0	0.5/0	0.5/1	0.5/0	0.3/0	1.0/1	1.0/0	0.5/0	0.5/0
SPB 290	9 M	500	0.6/0	0.7/0	0.6/0	0.0/0	0.7/0	0.6/0	0.6/1	0.7/0	0.2/0	1.0/1	1.0/0	0.6/0	0.4/0
SPB 291	7 M	500	0.8/0	0.9/0	0.8/0	0.0/0	0.8/0	0.7/0	0.8/1	0.8/0	0.2/0	1.0/1	0.7/0	0.8/0	0.4/0
SPB 292	5 M	500	1.0/0	1.0/0	1.0/0	0.0/0	1.0/0	0.9/0	1.0/1	1.0/0	0.1/0	1.0/1	0.6/0	1.0/0	0.4/0
SPB 293	16 M	600	0.5/0	0.4/0	0.4/0	0.0/0	0.3/0	0.3/0	0.4/1	0.4/0	0.3/0	1.0/0	1.0/1	0.4/0	0.6/0
SPB 294	14 M	500	0.4/0	0.5/0	0.4/0	0.0/0	0.4/0	0.4/0	0.4/1	0.5/0	0.2/0	1.0/0	1.0/0	0.4/0	0.6/0
SPB 295	12 M	500	0.6/0	0.6/0	0.6/0	0.0/0	0.6/0	0.5/0	0.6/1	0.6/0	0.2/0	1.0/1	1.0/0	0.6/0	0.6/0
SPB 296	10 M	500	0.7/0	0.7/0	0.7/0	0.0/0	0.7/0	0.6/0	0.7/1	0.7/0	0.1/0	1.0/1	0.7/0	0.7/0	0.5/0
SPB 297	8 M	500	0.8/0	0.9/0	0.8/0	0.0/0	0.7/0	0.7/0	0.8/1	0.9/0	0.1/0	1.0/1	0.6/0	0.8/0	0.5/0

*Proximity to oil spills/proximity to structures. See sections III K, L, and M for interpretations of information in this table.

APPENDIX 18

EFFECTS OF OIL ON MARINE ECOSYSTEMS

EFFECTS OF OIL ON MARINE ECOSYSTEMS

Pollution of the ocean by oil is a world-wide problem of growing concern to many nations. The magnitude of the problem is recognized by international organizations of governments and of industry, and has been the subject of several national and international conferences in recent years. The sources of oil in the marine environment have been studied by the Massachusetts Institute of Technology (1970) and by the U. S. Coast Guard (1972; see also Marine Transportation in volume 3 of this statement).

Hydrocarbons are not foreign to the marine environment; they are synthesized by most, if not all, living organisms. Unicellular algae can produce normal paraffin hydrocarbons from carbon dioxide, water and nutrients; paraffinic hydrocarbons are found in most living organisms of the sea (Clark, 1966; Clark and Blumer, 1967).

There are certain characteristic differences, however, between biologically produced hydrocarbons and pollution hydrocarbons, both in the distribution of various hydrocarbon classes and in the molecular size of the hydrocarbons. Crude oil and petroleum products are complex mixtures that contain molecules of different sizes in a fairly even distribution whereas living organisms utilize specific biosynthetic pathways that lead to specific hydrocarbon size groups (Personal communication to D. R. Evans from R. C. Clark, Jr., 1971).

Hydrocarbons are fat soluble and thus have the potential to be retained and accumulated in organisms (Blumer, et al , 1970, p. 17). The major hydrocarbon components in crude oil and in petroleum products can be classified with reference to known biological effects. These are summarized below.

Low-boiling, saturated hydrocarbons are related to the fat-soluble anaesthetics and have a narcotic effect on a wide variety of animals. In lower animals at low concentrations they often cause sleep or reversible insensibility. At higher concentrations they often cause cell damage and death, especially in larval and juvenile stages of marine organisms. The solubility of these low-molecular-weight hydrocarbons in water is of the order of 0.1 to 1.0 gram per liter (100 to 1,000 ppm), comparable to that of many drugs (Goldacre, 1968).

Low-boiling aromatic hydrocarbons comprise the most toxic petroleum fractions. The low-boiling aromatics are acutely poisonous to man and marine organism alike. Benzene, toluene and phenols, such as found in crude oil, produce in man reactions similar to those of alcohol. The initial reaction is restlessness, then excitement, inebriation, drowsiness, depression and sleep. Death may follow from respiratory failure as the concentration rises (Goldacre, 1968). Chronic exposure to low concentrations of some aromatics, especially benzene, may cause bone marrow disease chromosome aberration and leukemia (Finkel, 1960). Low-boiling aromatics, even more water-soluble than the saturates, can cause mortality of marine organisms by contact, even with dilute solutions (Blumer, 1970, p. 3).

Olefinic hydrocarbons are not generally found in crude oils but are plentiful in gasolines and other refined products. The fate of olefins in the marine environment is poorly understood, but this class of compounds is quite reactive and will combine readily with hydrogen, oxygen, chlorine, sulfur and other elements to produce toxic substances. Once incorporated into organisms, olefins remain stable. The full range of olefinic hydrocarbons is reported as likely to interfere with the reception of chemical messengers in the sea by marine organisms (Blumer, 1970, p. 6).

Higher-boiling, saturated hydrocarbons occur naturally in many organisms and, while probably not toxic at low levels, they may interfere with chemo-receptors, the communications system used by some organisms for locating food, responding to sex attractants, and for identifying migration routes (Blumer, 1969, p. 7; 1970, p. 6).

The higher-boiling aromatics act as slower poisons than the lower-boiling aromatic hydrocarbons, but they are equally severe in their effect; in addition, some are known to cause cancer. Benzpyrene, 1,2-benzanthracene and alkylbenzanthracenes have been isolated from crude oil and their carcinogenic effects on animals and man demonstrated (Blumer, 1970, p. 4).

A study of the available information on potential effects of oil pollution reveals more unknowns than proven conclusions. It thus is not at all clear what the acute and long-term effects of oil upon the environment and living marine resources of a region would be. Early reviews of the effects of oil upon bacteria and higher organisms (ZoBell, 1962, p. 85-117) reported no great impact of oil upon fishery resources in general, but are inconclusive because they also reveal incomplete general knowledge, particularly for north temperate, subarctic, and arctic regions. Even fairly recent work, including several studies of the Torrey Canyon, has depended upon on-site visual surveys after occurrence of the oil spill (Nelson-Smith, 1968; Smith, 1968; Simpson, 1968), rather than experiments and detailed study. These investigations have been limited mostly to effects of oil and cleaning or dispersing agents upon primarily adult intertidal organisms and populations. While these observations have contributed more understanding of the gross effects of oil, they have been unable to answer important basic questions on the effect of pollutant hydrocarbons in the marine environment.

Data gathered from on-site surveys of an oil spill, while descriptive of the effects of that spill, must be applied to other situations with caution. Straughan (1969, p. 309) reporting on investigations of the Santa Barbara oil spill noted factors unique to that incident: (1) the long history of natural oil seepage in the Santa Barbara Channel, and (2) unusually heavy winter run-off at the time of the spill which reduced salinities, increased sedimentation, and increased DDT in the channel. R. L. Kolpack (Personal communication cited in Kanter, et al , 1970, p. 487) noted that Santa Barbara crude oil is relatively insoluble in seawater and contains a very low percentage of light aromatic compounds. Thus, information gathered on the effects of the Santa Barbara spill are of limited utility in predicting the ecological effects of spills of other oils in other areas.

Lewis (1970, p. 6) commenting on approaches to the study of chronic pollution contends "...that without a massive expansion of ecological and reproductive data by simultaneous multi-disciplinary studies not only will we be unable to detect the significant long-term changes, but we will even remain unaware of the most suitable or important species and methods to build into a monitoring program." He notes our general lack of understanding of community structure and population dynamics which severely limits the interpretation of data and our predictive ability.

Copeland (1970, p. 831), discussing the response of ecological systems to stress, suggests the principle that "...those systems already subjected to energy requiring stresses are more likely to resist the changes than those (such as tropical systems) adapted to relatively constant environments." He concludes that estuarine ecosystems composed of organisms capable of wide adaptations and generalizations, such as north temperate systems, would be relatively unaffected by the same magnitude of disturbance that would drastically alter a tropical system. Odum (1970, p. 840) notes, however, that many estuarine species are living near the limit of their tolerance range and that any alteration in the environment, such as additional stresses caused by low levels of pollution or by decreased oxygen concentrations, could exclude these animals permanently from the estuary.

Studies of the effects of chronic low-level pollution upon subadult, larval and egg stages and the causes for changes in survival are extremely limited. Simply measuring plankton volume or counting species to evaluate the impact of an oil spill may not detect the physiological effects. Holmes (1969, p. 26) commenting upon his own observations that phytoplankton abundance and species composition were not much changed following the Santa Barbara oil spill noted, "...the effects of oil pollution upon the phytoplankton cannot be detected with the methods employed." Natural fluctuations of both vertebrate and invertebrate population levels often are such that qualitative or crude quantitative observations of a biological community might only reveal normal conditions unless a very large change was observed to correlate with the spill.

Because petroleum and petroleum products are toxic chemicals, to understand the action of these pollutants it is essential to utilize the resources of biochemistry and biophysics (Blumer, 1970, p. 13; FAO, 1970). Chemical pollution of the tissues of organisms can be detected by advanced analytic methods such as are employed by Blumer, Souza, and Sass (1970), and this work is opening new vistas of understanding of the effect of oil. The work of these latter authors suggests that the consequences of pollutant hydrocarbons in marine ecosystems is as yet not understood.

Blumer's (1969, p. 10) studies on the fate of organic compounds in the marine food chain found that hydrocarbons, once they are incorporated into a particular marine organism, are stable, regardless of their structure, and that they may pass through many members of the marine food chain without alteration and may actually be concentrated in tissue. This is a situation similar to the chlorinated hydrocarbon group of pesticides, which concentrate in the marine food chain to the point where toxic levels are reached.

The entrance of oil-derived hydrocarbons into marine food chains is evident. Smith (1968, p. 49) reported that the presence of oil and benzene-ring compounds in the feces of limpets browsing on an oily deposit has been demonstrated chemically; similar observations have been made on top-shells, *Monodonta*, and limpets, *Patella*, living on oily rocks at Perranuthnoe. He reported, "the proportion of oil in material ingested by these animals was estimated as about 20-30 percent in *Patella* and 5-50 percent in *Monodonta*." Smith (1968, p. 65) believed it unlikely that any food value to the browser is derived from such feeding activity. However, such feeding activity does concentrate hydrocarbons in organisms that in turn are eaten by larger animals and the oil thus enters the food chain.

Large amounts of tar were found in the stomachs of three saury, *Scomberesox saurus*, from a sample of ten in the Mediterranean Sea near Gibraltar by Horn, et al (1970, p. 246). Although these authors note that the saury is said to feed upon small crustaceans and perhaps upon small fish, they also note that "vegetable debris" was found in the stomach of one saury, which suggested the species is not a very discriminate feeder. They point out, however, that because this fish is fed upon by porpoises and larger predaceous fishes, a direct introduction into the ocean food web of material known to be toxic occurs. Mironov (1968, p. 336) notes the ability of some zooplankton organisms to accumulate hydrocarbons, assuring exposure at all trophic levels.

Some doubt may remain as to the direct carcinogenicity of crude oil and crude oil residues in marine organisms according to Blumer (1969, p. 9), but evidence pointing toward this is accumulating (Blumer, 1970, p. 4). A literature search and evaluation conducted for the U. S. Coast Guard by Battelle Memorial Institute (1967, pp. 6-19) noted that shellfish, although alive, may be unfit for consumption because of the carcinogenic hydrocarbon 3, 4-benzpyrene found in their bodies. Oysters that were heavily polluted and contaminated with ship fuel oil were also reported to contain 3, 4-benzpyrene. The Battelle review also reported barnacles attached to creosoted poles located in marine waters contained the same carcinogenic hydrocarbon (3, 4-benzpyrene), and it elicited sarcomas in mice when extracts from the barnacles were injected into the mice. The endemic occurrence of papillary tumors around the rectal opening of soft shell clams (Mya arenaria) was reported, but the author (Battelle Memorial Inst., 1967, pp. 6-19) did not feel these were due to oil pollution, even though the clams were taken from waters adjacent to areas highly polluted by ship fuel oil.

Aggregations of the planktonic forms of many pelagic and benthic organisms occur in the surface layer of the sea. This community of the surface 5 cm., the neuston, is the first affected by oil entering the water. Many planktonic larvae are phototrophic at their earliest stages and concentrate in this layer. Organisms in these early development stages appear most sensitive to oil pollution, coincidently with their period of greatest exposure.

Studies by Mironov (1968, p. 336) on the development of fertilized eggs of the plaice (Rhombus macoticus) showed extreme sensitivity of the eggs to the influence of oil products present in seawater. He noted that injury to the eggs occurred at concentrations of 10^{-4} to 10^{-5} ml/l (0.1 to 0.01 ppm). In these concentrations of oil products, 40 to 100 percent of the hatched pre-larvae showed some signs of degeneration during development and perished. Mironov (1969a) also demonstrated that 1 ppm crude oil was toxic to the eggs of anchovy, scorpion fish, and sea parrots from the Black Sea.

Larvae of Elinius modestus, an Australian barnacle introduced to Europe, are tolerant of 100 ppm crude oil but show a delay in setting of the cyprids (the final larval stage), while adults of this species can tolerate higher concentrations but show reduced activity at 100 ppm (Corner, et al, 1968). Mironov (1968, p. 337) reported that experiments with adult and post-larval stages of barnacles (Balanus sp.) showed the latter to be a hundred times more sensitive to oil pollution than the adult forms.

Decreased limb (cirral) activity of marine larvae exposed to oil has been reported (Smith, 1968, p. 135). Irreversible damage to cell membranes and granular contents of planktonic larvae may also occur. Goldacre (reference in Arthur, 1968, p. 161) has demonstrated such cytological damage and death to the freshwater protozoan, Amoeba proteus, exposed to crude oil fractions.

Mironov (1969b) tested crude oils on several copepods and a cladoceran, finding 1 ppm killed all forms within less than a day. Acartia and Calanus were reported (Mironov, 1968, p. 336) to succumb to 0.01 ppm oil in seawater in 72 to 96 hours. Although surviving longer than copepods, larvae of crab and shrimp also die at 1 ppm (Mironov, 1969c). Two of the copepods tested, Acartia clausi and Paracalanus parvus, occur in Alaskan waters.

Mironov and Lanskaya (1968) demonstrated that marine phytoplankton vary several orders of magnitude in sensitivity to crude oils and kerosine. Of the 20 species they tested (in oil concentrations ranging from 0.1 ppm to 1,090 ppm) Ditylum brightwellii, a diatom occasionally found in Alaska, was the most sensitive. The wide variation in susceptibility may account for the statements of low toxicity of crude oils to phytoplankton found in other reviews (Foyn, 1965; Davis, 1970; Nelson-Smith, 1970).

Cellular membranes of phytoplankton are damaged by the penetration of hydrocarbon molecules, which leads to the extrusion of cellular contents and to the penetration of oil into the cell. The hydrocarbons reduce the transpiration, probably by blocking the stomas and the intercellular spaces. The effects of oils on respiration are variable, but an increase of respiration is frequently observed, and may be due to an alteration of the mitochondria. This results in an uncoupling of the oxidative phorylation enzymes from the electron transport enzymes and the energy release is lost as heat. As for the detergents, if they are administered in a rather concentrated solution, their penetration into the plant cells will cause the dissolution of cellular membranes and the extrusion of cellular fluid (FAO, 1970, pt. 2, p. 6; Baker, 1971, p. 6).

Baker (1971, p. 37) reviewing the literature, noted that weathered Torrey Canyon oil had no apparent effect on photosynthetic activity of green algae, but that green algae treated with fresh crude oil died. Photosynthesis in kelp (Macrocystis) was reduced when exposed to various petroleum products.

Benthic organisms are also affected by oil entering on the surface waters. ZoBell (1962, pp. 99-100) reports oil is readily adsorbed by clay and silt, and suggests that although adsorption of oil by solids renders the oil more susceptible to autobial and microbial oxidation, almost no bacterial decomposition occurs after burial.

Suspended sediments carried by runoff from a major flood entered the Santa Barbara Channel area immediately prior to and after the well blowout. Adsorption of oil on the flocculated suspended particles followed by decomposition was a major factor in carrying much of the oil to the sea floor (Kolpack, 1970). Kinney, et al, (1970, p. 92) reported, however, that the glacial silt of Cook Inlet was observed to have no apparent effect on the emulsion properties or the sinking of that Alaskan crude oil.

In oil-producing areas, oil residues have often been observed on sandy beaches (ZoBell, 1962, p. 100) and in marshes and depths of water to 15.3 m. (Blumer, Sass, et al, 1970, p. 23). A portion of the fuel oil spilled into the harbor at Resolute, Northwest Territories, Canada, late in August 1970 went ashore there. On the basis of a casual sampling on September 3, 1970, the average penetration into the beach material was observed to be about 3 inches (7.6 cm) (Barber, 1971). Such oil may be buried and stay intact for a considerable time, even at the higher temperatures of the California coast (ZoBell, 1962, p. 100). Ramseier(Personal communication to D. R. Evans from R. O. Ramseier, 1971), discussing the behavior of oil in the Arctic, noted that practically no aging occurs to oil under ice, emulsification was negligible, and finally the process of biodegradation is not active at these temperatures of near $0^{o}C$ and below.

Blumer, Sass, et al (1970, p. 25) reported toxic components of No. 2 fuel oil present in bottom sediments the year following the West Falmouth oil spill and concluded the toxic properties of the oil slowed its biodegradation. This same spill provided a unique opportunity for the study of the immediate and long-term effects of an oil spill on an area where the previously existing environmental base was well known (Blumer, et al, 1971). One effect of the oil in the bottom sediments was to reduce the cohesion of bottom sediments of tidal marshes and the estuary by killing the benthic plants and animals. The resulting erosion spread hydrocarbons to new areas where the process was repeated. Because of the stability of the hydrocarbons in marine organisms and their persistence in bottom sediments, Blumer, et al (1971) concluded that a single oil spill could cause a chronic pollution problem in the vicinity of that spill.

ZoBell (1969, p. 320), discussing oxygen requirements for oil oxidation, noted that when oil oxidizers are in contact with the normal atmosphere, as at the air-water interface, the supply of oxygen is usually adequate. In areas of intense microbial activity below the water surface, particularly in bottom sediments, oxygen may be a limiting factor. This depends upon how rapidly oxygen is consumed and how rapidly it is replenished. Replenishment may be by oxygen diffusion, water turbulence, or photosynthetic activity in shallow water. Calculating average BOD (Biochemical Oxygen Demand) requirements for various crude oil fractions, he estimated it would require all of the dissolved oxygen in about 320,000 gallons of seawater for the complete oxidation of 1 gallon of crude oil. The complete oxidation of oil would require all of the dissolved oxygen in about 40 acre feet of seawater assuming replenishment from the atmosphere or photosynthetic activity.

Blumer (1970, p. 12) summarizes the potential damage to marine ecology from pollution with crude oil and oil fractions as follows:

1. Direct kill of organisms through coating and asphyxiation.
2. Direct kill through contact poisoning of organisms.
3. Direct kill through exposure to the water-soluble toxic components of oil at some distance in space and time from the accident.
4. Destruction of the generally more sensitive juvenile forms of organisms.
5. Destruction of the food sources of higher species.
6. Incorporation of sublethal amounts of oil and oil products into organisms resulting in reduced resistance to infection and other stresses (the principal cause of death in birds surviving the immediate exposure to oil).
7. Incorporation of carcinogenic and potentially mutagenic chemicals into marine organisms.
8. Low level effects that may interrupt any of the numerous events necessary for the propagation of marine species and for the survival of those species which stand higher in the marine food web.

A recent technical conference in Rome, Italy, on the subject of marine pollution and its effects on living marine resources and fishing (FAO, 1970) provided the following summary:

> "Crude petroleum is a complex mixture of natural products and includes many thousands of different compounds. Although crude oils differ markedly in their physical properties, the basic chemical, biological,

and toxicological properties of crude oil are quite similar. Petroleum and its hydrocarbons have been found to be remarkably stable in the marine environment. Although hydrocarbons that are dissolved in the water column are eventually destroyed by bacteria, the most toxic compounds are the ones that are the most refractory."

"The immediate short-term effects of oil pollution are rather obvious. However, some of the most serious aspects of oil pollution deal with the low-level toxic effects, particularly on young forms of marine animals. The great complexity of the marine organisms present a potentially dangerous situation which may adversely affect our fisheries resources. Hydrocarbons may not only be retained, but they may also be concentrated and become protein bound. Thus, petroleum may contribute to the destruction of food values through the incorporation of oil and oil products into fisheries resources."

REFERENCES CITED

Arthur, D. R., 1968, The biological problems of littoral pollution by oil and emulsifiers—A summing up; in Carthy and Arthur (Eds.): The biological effects of oil pollution on littoral communities, pp. 159-164.

Baker, J. M., 1971, The effects of oil on plants; Environ. Pollut, 1(1): 27-44.

Barber, F. G., 1971, An oiled arctic shore, Arctic 24:3.

Battelle Memorial Institute, 1967, Oil spillage study; literature search and critical evaluation for selection of promising techniques to control and prevent damage; 8 sections including biological and ecological effects, Dept. Commerce Clearinghouse for Scien. and Tech. Information.

Blumer, Max, 1969, Oil pollution of the ocean in Oil on the Sea, David P. Hoult, ed., pp. 5-13, Plenum Press.

____________, 1970, Scientific aspects of the oil spill problem; Presented at NATO Conference, Brussels, Nov. 6, 1970. 21 pp., mimeo, Woods Hole Oceanographic Institute, Woods Hole, Mass.

Blumer, M., Sanders, H. L., Grassle, J. F., and Manson, G. R., 1971, A small oil spill: Environment, 13:2.

Blumer, M., Sass, J., Souza, G., Sanders, H., Grassle, F., and Hampsan, G., 1970, The West Falmouth oil spill: Ref. No. 70-44, 32 pp., 18 fig., mimeo. Unpub. ms. Woods Hole Oceanographic Institute, Woods Hole, Mass.

Blumer, M., Souza, G., and Sass, J., 1970, Hydrocarbon pollution of edible shellfish by an oil spill: Mar. Biol. 5:195-202.

Clark, R. C., Jr., 1966, Occurrence of normal paraffin hydrocarbons in nature. Technical Report 66-34, Woods Hole Oceanographic Institution, Woods Hole, Mass., 56 pp. (processed).

Clark, R. C., Jr. and Blumer, M., 1967, Distribution of N-paraffins in marine organisms and sediment: Limno. Oceanog. 12:79-87.

Copeland, B. J., 1970, Estuarine classification and responses to disturbances: Trans. Am. Fish. Soc., 99(4):826-835.

Corner, E. D. S., Southward, A. I., and Southward, E. C., 1968, Toxicity of oil spill removers ('Detergents') to marine life: An assessment using the intertidal barnacle Elminius modestus: Jour. Mar. Biol. Assoc. UK 48:29-47.

Davis, C. C., 1970, The effects of pollutants on the reproduction of marine organisms: FAO Tech. Conf. on Marine Pollution and its Effects on Living Resources and Fishing, Rome, Italy, 9-18 Dec. 1970, 13 pp.

FAO, 1970, Technical conference on marine pollution and its effects on living resources and fishing: Draft Report, Part 3, Section VI, Rome, Italy.

Finkel, M. J., 1960, Benzene, in the Merck Index of Chemicals and Drugs: Merck and Co., Rahway, p. 129.

Foyn, Ernst, 1965, Disposal of waste in the marine environment on the pollution of the sea: *Oceanog. Mar. Biol. Ann Ve.* 3:95-114.

Goldacre, R. M., 1968, Effects of detergents and oil on the cell membrane *in* The biological effects of oil pollution on littoral communities: (Suppl. to Field Studies, vol. 2), ed. by J. D. Carthy and D. R. Arthur, Field Studies Council, London, pp. 131-137.

Holmes, R. W., 1969, The Santa Barbara oil spill, *in* Oil on the Sea: David P. Hoult, ed., pp. 15-28, Plenum Press.

Horn, M. N., Teal, J. M., and Backus, R. H., 1970, Petroleum lumps on the surface of the sea: *Science* 168:245-246.

Kanter, R., Straughan, D., and Jessee, W. J., 1970, Effects of exposure to oil in *Mytilus californianus* from different localities: *in* Prev. and Cont. of Oil Spills, pp. 485-488, A.P.I., New York, N. Y.

Kinney, P. J., Button, D. K., Schell, D. M., Robertson, B. R., and Gover, J., 1970, Quantitative assessment of oil pollution problem in Alaska's Cook Inlet: U. of Alaska Institute of Marine Science Report R69-16, 116 pp., College, Alaska.

Kolpack, R. L., 1970, Oil spill at Santa Barbara, California - Physical and chemical effects Biological and oceanographical survey of the Santa Barbara Channel oil spill, 1969-70: Allan Hancock Foundation.

Lewis, J. R., 1970, Problems and approaches to baseline studies in coastal communities: Presented at FAO Tech. Conf. Mar. Poll., 7 pp., mimeo, Rome, Italy.

Massachusetts Institute of Technology, 1970, Man's impact on the global environment: Report of the study of critical environmental problems, sponsored by M.I.T. Press.

Mironov, O. G., 1968, Hydrocarbon pollution of the sea and its influence on marine organisms: Helgolander wiss. mecresunters, 17:335-339.

________, 1969a, The development of some Black Sea fishes in sea water polluted by petroleum products: Voprosyikhtiologiia, 9(6)(59): 1136-1139.

________, 1969b, Effects of oil pollution on some representatives of the Black Sea zooplankton: Zool. zh. 48(7):980-984.

________, 1969c, Viability of larvae of some crustacea in sea water polluted with oil products: Zool. zh. 48(1):1734-1737.

Mironov, O. G., and Lanskaya, L. A., 1968, Survival of some marine plankton and benthoplanktonic algae in sea water polluted with petroleum products: Bot. zh. 53(5):662-669.

Nelson-Smith, A., 1968, Biological consequences of oil pollution and shore cleansing, *in* Carthy and Arthur (editors): The biological effects of oil pollution on littoral communities, pp. 73-80.

________, 1970, The problem of oil pollution in the sea: Adv. Mar. Biol., 8:215-306.

Odum, W. E., 1970, Insidious alteration of the estuarine environment: Trans. Am. Fish. Soc., 99(4):836-846.

Simpson, A. C., 1968, The *Torrey Canyon* disaster and fisheries: Min. Agri., Fish and Food. Lab. Leaflet (new ser.) 18, 43 pp.

Smith, J. E. (ed.), 1968, *Torrey Canyon* pollution and marine life: A report by the Plymouth Laboratory of the Marine Biological Association of the United Kingdom, Cambridge University Press, London, 189 pp. and 29 pls.

Straughan, Dale, 1969, The Santa Barbara study, *in* Prev. and Control of Oil Spills: A.P.I., New York, N.Y., p. 309-311.

U. S. Coast Guard, 1972, Marine transportation systems related to trans-Alaska pipeline system: Report done for U. S. Dept. of the Interior, February 1972.

ZoBell, C. E., 1962, The occurrence, effects and fate of oil polluting the sea: Int. Conf. on Water Pollut. Res., pp. 85-117.

______, 1969, Microbial modification of crude oil in the sea: Proc. Joint Conf. Prev. and Cont. Oil Spills, Am. Pet. Inst., New York, p. 317-326.

APPENDIX 19

MEMORANDUM OF UNDERSTANDING BETWEEN BLM AND USGS FOR PIPELINES

MEMORANDUM OF UNDERSTANDING BETWEEN THE BUREAU OF LAND MANAGEMENT AND THE GEOLOGICAL SURVEY FOR OUTER CONTINENTAL SHELF PIPELINES

This Memorandum of Understanding is entered into in order to define clearly the administrative and operational roles of the Bureau of Land Management (BLM) and the Geological Survey (USGS) relating to pipelines on the Outer Continental Shelf (OCS), to provide consistent and standardized procedures, and to minimize or eliminate dual and overlapping functions.

Unless otherwise provided herein, pipelines are defined as any line transporting oil, gas, water, sulphur or other minerals, including lines sometimes referred to as flow or gathering lines.

The objectives of this Memorandum of Understanding are to:

A. Provide an efficient mechanism for approving pipeline routes through the submerged lands of the OCS.

B. Initiate measures to provide safety and to minimize or eliminate environmental damage which may be associated with the installation and operation of pipelines originating on the OCS.

C. Be responsive to the interests of the oil and gas industry, other users of the OCS, and the public with respect to pipelines.

D. Streamline implementation of the regulations and procedures for more efficient and uniform administration of the Department's authority with respect to pipelines.

PIPELINE MANAGEMENT

I. BLM ROLE

A. Conduct pipeline routing studies and, with the concurrence of the USGS, designate pipeline corridors on the OCS for all pipelines other than flow or gathering lines within the confines of a single lease or group of contiguous leases under unitized operation or a single operator.

B. Maintain a central office of record for the location of all existing and future pipelines as specified in paragraph I.A. and associated structures on the OCS.

C. Receive applications for rights-of-way for pipelines to be installed on the OCS pursuant to 43 U.S.C. 1334(c) and 43 CFR 2883.

D. Prepare environmental assessments, pipeline system planning studies, economic studies, and environmental impact statements when necessary or appropriate, prior to approving applications for rights-of-way pursuant to 43 U.S.C. 1334(c) and 43 CFR 2883.

E. After considering the potential impact of the pipeline on the environment, the relationship of the application to existing pipeline routes on the OCS, and other factors, approve or disapprove the application pursuant to 43 CFR 2883.

F. Conduct field studies relating to the long range environmental impact of all pipelines and associated structures, thereby providing a basis for continuous assessment of existing environmental safeguards applied to such pipelines.

II. USGS ROLE

A. Consider all applications from a lessee or operator for a right of use and easement to construct and maintain pipelines and associated structures on the OCS pursuant to 30 CFR 250.18 and 250.19. Prior to granting approval of such applications for any pipeline other than flow or gathering lines within the confines of a single lease or group of contiguous leases under unitized operation or a single operator, consult with the BLM so that the routing of such pipelines may be coordinated with existing lines or designated pipeline corridor.

B. Review technical aspects of OCS pipeline design, installation, maintenance and operation in accordance with appropriate regulations and standards designed for safety and environmental protection, and to avoid undue interference with other uses of the OCS and its superjacent waters.

C. Prepare environmental assessments or impact statements when necessary prior to approving applications filed pursuant to 30 CFR 250.18 and 250.19.

D. Provide the BLM with the location, as installed, of all pipelines approved by the USGS as specified in paragraph II.A.

PROCEDURES

1. BLM will receive right-of-way applications pursuant to 43 CFR 2883 for pipelines and associated structures for the transportation of oil, gas, sulphur and other minerals on the OCS. A copy of the application will be sent to USGS for review. The reviews by USGS will focus on the technical aspects of OCS pipeline design, installation, maintenance and operation in accordance with appropriate regulations and standards designed for safety and environmental protection, and to avoid undue interference with

other uses of the OCS and its superjacent waters. The BLM will issue a decision granting the right-of-way after having been notified in writing by the USGS that the technical aspects of the proposed pipeline are acceptable. BLM will prepare environmental assessments and impact statements prior to granting such pipeline rights-of-way when necessary or appropriate.

2. The USGS will approve rights of use and easement for gathering and flow lines pursuant to 30 CFR 250.18 and 250.19. For any such pipelines other than flow or gathering lines within the confines of a single lease or group of contiguous leases under unitized operation or a single operator, the USGS will transmit a copy of the pipeline application to the BLM. The BLM will review the application as to whether the pipeline route conflicts with any existing or proposed pipeline and pipeline corridors or would otherwise not be consistent with good pipeline management for the OCS. The BLM will advise the USGS in writing of the results of its review prior to a USGS determination for approval or disapproval of the application.

3. The BLM will conduct field studies relating to the immediate and long term environmental impact of pipelines and associated structures on the OCS in order to assess the adequacy of environmental safeguards. Reports of the results of the BLM field studies with recommendations for minimizing the impact of pipelines on the environment will be released to the public and distributed to appropriate agencies with jurisdiction over pipelines on the OCS.

4. The BLM and USGS will periodically review existing procedures for reviewing applications and issuing rights-of-way and rights of use and easements and propose improvements in such procedures as appropriate. The procedures shall include the assessment of the environmental impact and the minimization of the number and locations of pipelines on the OCS.

5. The BLM and USGS will consult with each other in the preparation of environmental analyses and impact statements and will also consult with the Bureau of Sport Fisheries and Wildlife, the National Park Service, the Bureau of Outdoor Recreation, and other Federal and State agencies as appropriate.

6. The BLM will assume the responsibility for overall studies of pipeline routing on the OCS and, with the concurrence of the USGS, designate pipeline corridors for all pipelines other than flow or gathering lines within the confines of a single lease or group of contiguous leases under unitized operation or a single operator. To assist

in this, the USGS will furnish BLM with a copy of all approvals and drawings showing the proposed and installed locations of all pipelines, as described in this paragraph, and associated structures erected in connection with approvals of rights of use and easements.

AUG 1 1974	AUG 1 1974
Date	Date
V. E. McKelvey	George L. Turcott
Director, USGS	Director, BLM

APPENDIX 20

EXCERPT OF FIFTEEN RECOMMENDATIONS FROM A REPORT ISSUED BY A SPECIAL WORK GROUP OF THE USGS MAY 1973, IN RESPONSE TO OCS SAFETY AND POLLUTION

Recommendation No. 1. Failure Reporting and Corrective Action

Action Taken: OCS Order No. 5 for the Gulf of Mexico has been revised and now requires operators to submit quarterly failure-analysis reports on subsurface safety devices. The Gulf Coast Offshore Operators' Committee is developing procedures for closed loop failure reporting and corrective action system which will include all critical platform safety components. The output from these systems is computerized and will be analyzed by the safety review committee.

The Pacific Area has been furnished the Gulf of Mexico Area revised OCS Order No. 5 for consideration and adaptation to the Pacific Area. The Pacific Area OCS Order No. 5 presently requires surface-controlled subsurface safety devices.

Recommendation No. 2. Accident Investigation and Reporting

Action Taken: The legality of publishing investigation reports of major accidents has been affirmed by the Solicitor's Office of the Department of the Interior. The Regional offices of the Geological Survey are developing accident investigation reporting procedures which are more responsive to cause and effect relationships. The Pacific Area has performed a study on the advisability of statistics of accidents per man-hours worked by companies and reviewed all forms used in accident reporting.

Recommendation No. 3. Information Exchange

Action Taken: A "Safety Alert" system has been initiated in the Pacific Area and Gulf of Mexico Area. With this system operators are advised of accidents occurring during OCS drilling and producing operations to let the industry know immediately of its own mistakes and malfunctions so that improvements can be made where applicable. It is anticipated that an information dissemination system will be designed during the next fiscal year to provide industry with the results of the failure reporting and corrective action systems, accident investigations, inspections, and other elements of the lease management program.

Recommendation No. 4. Research and Development

Action Taken: A cooperative committee on offshore safety and anti-pollution research has been formed in conjunction with the American Petroleum Institute (API). The purpose of the committee is to determine the research and development efforts being undertaken by industry and Government in this area; determine specific needs for additional efforts; and to contract research and development in areas where industry response is lacking or unsatisfactory.

Recommendation No. 5. Standards and Specifications

Action Taken: A cooperative committee on offshore safety and anti-pollution standards has been formed in conjunction with the API. This committee's function is to establish standards and specifications for safety and anti-pollution equipment. The first project undertaken by the committee was recommended practice for design, installation and operation of subsurface safety valve systems and specifications for subsurface safety valves. Draft copies of these standards have been made available for review and comment. The final copies of these standards will be published later in 1974. In connection with this, a facility for the testing of subsurface safety valves will be constructed and operated by an independent research institute.

With regards to existing devices, the Offshore Safety and Anti-Pollution Committee (OSAPE) reports that the procedures and requirements set forth in API Spec. 14-A and RP 14-B will enable the Industry to identify problem areas and improve the reliability of subsurface safety valves (SSSV's). Specifically API 14-A requires SSSV performance and functional testing, manufacturer quality assurance programs, and operator failure and malfunction reporting with resulting operator-manufacturer analysis. API RP 14-B and 14-B(S) provide updated installation and maintenance procedures in addition to an accurate computer program for sizing subsurface controlled subsurface safety valves. Therefore, the OSAPE Committee feels that the areas identified by Industry for additional SSSV research such as operational reliability, performance testing, design analysis and sizing, and seating and control hardware will all be addressed in API 14-A and 14-B. In addition, the two currently active API research projects on SSSV orifice coefficients and sand erosion are of highest priority and will also help establish better SSSV sizing calculations and improve SSSV reliability. In summary, the OSAPE Committee does not feel that additional research on existing SSSV equipment should be initiated until SSSV performance data generated from the use of API 14-A and 14-B has been gathered and analyzed and the two previously mentioned research projects have been completed.

Pacific Area and Gulf of Mexico area engineers are participating in these committee meetings. The API, the Offshore Operations Committee of the Gulf of Mexico and the Western Oil and Gas Association (WOGA) of the west coast have been, and are continuing to work with the U. S. Geological Survey in making meaningful and effective changes in OCS operations.

Recommendation No. 6. System Analysis

Action Taken: System analyses were performed on 13 installations in the Gulf of Mexico under two Geological Survey contracts. These studies are currently being evaluated with the objective of possible adoption into the lease management program in connection with the work being done in this area by the committee on standards and specifications.

Exxon, in its effort to provide an environmentally and functionally safe system for the Pacific Area, Santa Barbara Channel, Santa Ynez Unit, contracted with General Electric to make a Functional Systems Analysis (Hazard Analysis) of the initial Hondo Field development. The study looked in detail at the offshore production facilities, the pipelines to shore, and the alternate offshore storage and terminal system from the viewpoint of safety to personnel and oil in water pollution.

The study concludes that of 2,400 functional components studied, only 28 were in need of additional analysis and with suggested design improvements would render the systems very safe.

It was also concluded that for a facility of its size and complexity, the proposed Santa Ynez Unit facilities had minimal problems when compared to similar facilities studied by General Electric in the Gulf of Mexico.

Volume 1 of The Functional Systems Analysis for the initial Santa Ynez Unit, Hondo Field development was submitted to the U. S. Geological Survey.

Recommendation No. 7. Engineering Documentation

Action Taken: This recommendation has been fully implemented in the Pacific Area to the extent that all of the recommended documentation is in each operator's field office. Similar documentation is in the U. S. Geological Survey Area and District offices except for parts lists and specifications for all functioning components. The current Pacific Area OCS Order No. 8 requires this information to a large degree although, in some cases, the particular items recommended for documentation are not specifically addressed. Thorough inspection practices have assisted in accomplishing this implementation. However, the Pacific Area will review the Gulf of Mexico revised OCS Order No. 8, when completed, for consideration and possible adaptation to the Pacific Area.

Recommendation No. 8. Wearout Prevention

Action Taken: The proposed revision of Gulf of Mexico Area OCS Order No. 8 includes an erosion control program.

This is also the subject of one of the research and development committee's projects. The Pacific Area will review the Gulf of Mexico Area OCS Order No. 8, when completed, for adaptation of the erosion control section to the Pacific Area.

Recommendation No. 9. Training

Action Taken: A committee has been formed in conjunction with the API on offshore safety and anti-pollution training and motivation. This committee is outlining the training needed for personnel working offshore, setting up training programs, and establishing a time framework for accomplishing this. The Geological Survey is establishing a more formalized training program for their own personnel and have plans for developing a training course in OCS Orders and regulations for presentation to the industry. The Pacific Area has made a study for formal training available on the Pacific Coast. Training programs will be coordinated with the Gulf of Mexico Area.

During April 1974, Geological Survey technicians from the Gulf Coast and Santa Barbara Channel attended training courses consisting of ten sessions. Each session covered a different subject and was conducted by a different instructor with appropriate expertise. The basic course objective was to improve pollution prevention and control.

Recommendation No. 10. Motivation Program

Action Taken: The API and oil industry are taking the lead in developing a motivation program.

Recommendation No. 11. Lease Management Program

Action Taken: Additional personnel have been hired for the Pacific Area and Gulf of Mexico Area OCS offices. The areas of responsibilities and goals of the individual organizational units are being developed. Also under development, is a system for incorporating reports from other program areas into an annual review.

Recommendation No. 12. Inspection Procedures

Action Taken: Data processing equipment has been installed in the Gulf of Mexico Area office. Inspection checklists are being updated to keep current with OCS Orders. Special inspections are conducted bi-monthly as data gathering exercises. Consistent enforcement policy is being applied in each OCS area. Computerized data files regarding inspections, platforms, and accidents have been established and are used as input for the safety review committee.

The Pacific Area has reviewed formalized inspec- procedures for the Gulf of Mexico Area and fully implemented similar enforcement inspection procedures.

Recommendation No. 13. OCS Order Development Procedures

Action Taken: The Geological Survey is currently developing formalized procedures for the evaluation and revision of existing OCS Orders and the development of new OCS Orders. Proposed new and revised Orders are to be published in the *Federal Register* for public comment prior to their adoption. The Pacific Area has recommended specific revisions of OCS Order No. 2 and is reviewing other OCS Orders for revision.

Recommendation No. 14. Standardization of Pollution Report Form

Action Taken: The Pacific Area has reviewed the Gulf of Mexico Area proposed form and has submitted suggestions and comments.

Recommendation No. 15. Safety and Advisory Committees

Action Taken: The industry has established a committee on OCS Safety in both the Pacific and Gulf of Mexico Areas. The Area offices have designated personnel to form systems analysis review committees to meet on a regular basis. These committees have had their initial meetings and will continue meeting monthly to review prior accidents and accident reports and discuss implementation of safety programs.

The Director of the Geological Survey has formed a review committee on safety of OCS petroleum operations. This committee is composed of experts not regularly employed by industry or the Government and is sponsored by the Marine Board of the National Academy of Engineering. The initial meeting of this committee was held in Washington, D. C., during August 1973.

APPENDIX 21

REPORT OF THE WORK GROUP ON OCS SAFETY AND POLLUTION CONTROL
U.S. GEOLOGICAL SURVEY

Abbreviations Used In The Report

AEC - Atomic Energy Commission

ANSI - American National Standards Institute

API - American Petroleum Institute

ASME - American Society of Mechanical Engineers

ASTM - American Society for Testing and Materials

EPA - Environmental Protection Agency

FAA - Federal Aviation Agency

LMS - Lease Management Study (conducted by a team of systems analysts from the U.S. Geological Survey)

NAE - National Academy of Engineering (specifically a panel of the Marine Board who conducted a study of OCS safety)

NASA - National Aeronautics and Space Administration (specifically the team of NASA analysts who conducted a study of OCS operations)

NOAA - National Oceanic and Atmospheric Administration

OCS - Outer Continental Shelf

OOC - Offshore Operators Committee (Gulf of Mexico)

USCG - United States Coast Guard

USGS - United States Geological Survey

WOGA - Western Oil and Gas Association

Foreword

The Director, U.S. Geological Survey (USGS) appointed a Work Group to review the findings of three studies conducted at the request of the USGS on improving safety and pollution control in the management of Outer Continental Shelf oil and gas operations, and to recommend appropriate implementation actions. The studies are identified in the Appendix.

This report is not only responsive to the specific recommendations of the studies, but also reflects findings from meetings with personnel from the American Petroleum Institute, the Offshore Operators Committee, the Western Oil and Gas Association, a panel of the Marine Board, National Academy of Engineering, NASA, Occupational Safety and Health Administration, the Department's Office of the Solicitor, and others.

Several actions have already been taken where an immediate response was considered necessary or desirable. For example:

- Contracts studies have been made to determine requirements for implementation of systems analysis reviews.
- The Marine Board, National Academy of Engineering, has agreed to establish a Review Committee on Safety of OCS Petroleum Operations.
- Action was initiated to expand OCS Accident Investigation Procedures to include an immediate notification, after the occurrence of an accident, to all OCS lessees and operators of potentially hazardous situations (Safety Alert).
- The Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the U.S. Coast Guard have been requested to participate in the implementation of appropriate recommendations of the NAE study.
- Opinions have been obtained from the Department of Justice and the Office of the Solicitor on the legal aspects of certain implementation actions.
- Arrangements were made for API cooperation in the implementation of those recommendations calling for its participation.
- Safety committees have been established in the Offshore Operators Committee and the Western Oil and Gas Association.

Similarly, the Conservation Division of the U.S. Geological Survey, which has the regulatory responsibility for OCS activities, has already responded to various recommendations as a result of direct discussions the Work Group has had with them during the course of the study. For example, inspection procedures developed in the Lease Management Study have been implemented.

The report is organized in sections by subject. Each section contains the related recommendations from the three study reports, some remarks, the Work Group's recommendation, and finally the implementation action required.

1. FAILURE REPORTING AND CORRECTIVE ACTION

RECOMMENDATIONS OF STUDIES

NASA--*It is therefore recommended that USGS lay the groundwork for the type of activity, described above* (a closed-loop, failure reporting and corrective-action program), *in the drilling and production phase of the oil industry by requiring monthly summaries from each operator of failure causes and corrective action taken for all safety equipment specified by OCS Orders. All accidents and oil spills should follow similar procedures. For the procedure to be effective, its object should be recurrence prevention, with emphasis placed on the determination of causes, preventive action, and follow-up.*

This recommendation, if adopted, will have a significant impact, primarily due to the change in policy made necessary by the majority of offshore operators. The statement is often made by offshore people that "the only real test of equipment is to place it in service in the Gulf".

Whether this is a valid assumption or not, the data from this "test" should be utilized to maximum advantage. The basic philosophy to be followed is that every failure has a cause, every cause can be understood, and every failure can be corrected or alternate procedures provided.

REMARKS

In order to promote technological improvements in equipment necessary for safe offshore operations, and to reduce the occurrence of equipment malfunctioning, all operators should develop a systematized method for failure identification. In many cases, malfunctioning equipment has been replaced or repaired with little or no attempt made to determine the reason for failure. Consequently, a piece of equipment with an inherent failure problem might continue to be used and replaced for a period of time before the reason for continual failure is discovered. In conjunction with an analysis of failures, a corrective action program is necessary to guard against a recurrence of the same type of failure. Implementation of NASA's recommendation would tend to encourage operators to work more closely with their suppliers to determine and remedy causes of equipment failures. Analysis of accidents and oil spills would help to identify items for closer inspection and to determine patterns of equipment failure.

OCS Order No. 5, revised effective June 5, 1972, requires a quarterly failure analysis report for subsurface safety devices. Initial experience with this system should indicate the most favorable manner in which to proceed with failure reporting on other equipment.

WORK GROUP RECOMMENDATION NO. 1

It is recommended that the USGS require all operators to establish an internal failure-reporting, corrective-action program, to include: 1) an operator's report to the USGS on incidents, problems, and failures which result in fires or reportable oil spills or reportable accidents; 2) the factual circumstances surrounding the incident; and 3) the corrective actions taken. The operator's report to the USGS should be required on a scheduled basis. Data from the reports should be computerized to facilitate analyses and corrective actions. Implementation of this recommendation should not preclude compliance with the existing requirements for immediate reporting of serious accidents, all fires, and spills as specified in 30 CFR 250.43 and 250.45, and pertinent OCS Orders.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should determine the requirements for reporting and include them in OCS Orders. For those cases where the OCS Orders cannot be issued within a reasonable period of time, notices, as appropriate, should be issued to all operators.

2. ACCIDENT INVESTIGATION AND REPORTING

RECOMMENDATIONS OF STUDIES

NAE --*The official reports stemming from investigation of major accidents should receive prompt and full public disclosure, and should be available in a readily accessible form.*

The U. S. Government should directly sponsor, encourage, and provide the means for a public exchange of information on the causes and effects of accidents, and on the performance of specific items of safety-related equipment in the offshore industry.

A careful analysis should be carried out after every major offshore oil spill to determine the precise manner in which the spill occurred -- taking into account any equipment failures, personnel errors, or design inadequacies, their causes and what can be done to prevent such future occurrences.

The information resulting from accident investigation and evaluation of component performance should be analyzed by a competent organization (similar to the National Transportation Safety Board or the Marine Safety Council), and its conclusions should be made public promptly.

REMARKS

The Conservation Division established, on April 12, 1971, a procedure for "Notification and Investigation of Accidents". This procedure is designed to provide prompt investigation and systematic review of accidents as a basis for taking immediate corrective actions to limit the probability of recurrence. No provision is made, however, for public disclosure of findings such as is practiced by the U.S. Coast Guard and the Federal Aviation Agency. Publication of accident investigation results is desirable to develop public confidence in, and acceptance of, petroleum operations offshore.

The Assistant Solicitor in his memorandum of January 10, 1973, to the USGS stated that, "...there does not seem to be any legal objection to the publication of such reports. However, it is necessary to be careful about the content of the report published. For example, any proprietary information should be deleted before publication. Moreover, the report should be limited to factual statements and should not include judgments on the conduct of companies or personnel. The Geological Survey should consult the Solicitor's Office before publishing any reports".

WORK GROUP RECOMMENDATION NO. 2

The Work Group agrees with all four recommendations of the NAE Study, i.e.:

a. Reports of major accidents stemming from the current USGS procedure for investigation of accidents should be made available to the public promptly.

b. Work Group Recommendation No. 3, calling for a system for disseminating information concerning equipment failures and accidents, should include a means for the public to have access to the information.

c. Analyses of causes of major oil spills should be made as part of the accident investigation procedure and, if required, by additional follow-up studies. Results of all such analyses should be provided to the Review Committee (see Work Group Recommendation No. 15).

d. Results of accident investigations, in addition to being made available to the public, should be provided to the Review Committee for possible further analyses.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should begin immediately to implement the above recommendations. They will need to determine the format and means of disseminating reports to the public and consult with the Solicitor's Office prior to release.

Referral of appropriate items to the Review Committee should be done by the Director, USGS.

3. INFORMATION EXCHANGE

RECOMMENDATIONS OF STUDIES

NASA--*It is recommended that the USGS investigate the legal question of a possible anti-trust law violation regarding formal exchange of hardware and method problem information within the oil and gas industry. If a favorable ruling is obtained, USGS should encourage and participate in the development and operation of the system.*

As an alternative, USGS could become the focal point for this information and disseminate it to all concerned parties.

NAE --*In addition to, and separate from the inspection procedures, there should be a government-sponsored system of reporting safety-related information for the purpose of improving the safety of offshore operations and the inspection system by additions and eliminations. This system, in order to be effective, must take into consideration and allow for the problems of self-incrimination.*

REMARKS

To utilize fully the information gathered through a failure and accident reporting and corrective action program, it will be necessary to disseminate such information throughout the offshore petroleum industry. NASA has noted that it has been successful in providing a rapid exchange of information in the space program which has been one of the keys to its success. The Atomic Energy Commission also employs procedures to notify all AEC installations of accidents, their causes, and remedial actions to prevent recurrences.

WORK GROUP RECOMMENDATION NO. 3

The USGS should establish and operate a system for disseminating information concerning equipment failures and accidents, utilizing data obtained through a failure and accident reporting and corrective action program, operator reports, and investigations conducted by the USGS. Such information should be made readily available to the public.

A system should also be established for immediate notification to all operators of a potential failure or accident as a result of specific incidents, prior to a full investigation and final dissemination of information.

IMPLEMENTATION ACTION REQUIRED

In view of the mass of data to be handled, and the intricacies of a system for evaluating, cataloging, and dissemination of information, the USGS should contract for the design by data-bank specialists. Due consideration should be given to the possible adaptation to USGS needs of dissemination systems used by other agencies such as NASA, AEC, FAA, and others.

A "Safety Alert" system for immediate notification to all operators of failures and accidents has already been implemented.

4. RESEARCH AND DEVELOPMENT

RECOMMENDATIONS OF STUDIES

NASA--It is recommended that USGS establish a method to determine needs and conduct or direct the research, testing and development necessary to improve equipment and methods for an increasingly safe and pollution-free operation on the OCS.

An alternate recommendation is that USGS work with the industry in establishing an organization such as the American Petroleum Institute (API) to serve as the R&D focal point, with all companies contributing toward resolution of problems.

NAE --The U. S. Government should encourage and utilize industry research and development programs by means of promotion of industry consensus standards on offshore technology so that it can act to ensure that information on improvements in safety technologies becomes available to participants in offshore resource development.

The U. S. Government should sponsor a coordinated program to specify reasonable limits of crude oil intrusion in accordance with biological and aesthetic standards. These standards should be set in a manner that will take full account of site variables. The effort should be carried out on a continuing basis in order to take advantage of improvements in the technology of offshore petroleum operations. The program should be specifically directed to provide a basis for engineering design and standards for components and systems to be used in offshore petroleum operations.

The U. S. Government should make quantitative studies of the effectiveness of the various present and potential methods of cleaning up oil from the marine environment, and of their potential marine environmental impact.

The U. S. Government should actively encourage and sponsor the development and testing of damage-limiting and fail-safe systems and techniques in the areas of damage control, fire-fighting, and well control.

REMARKS

Considerable research has been conducted by various segments of the petroleu industry and by certain governmental agencies in matters related to offshore drilling and producing operations. In the past, however, development of additional safety controls by the industry often resulted only as a side effect from the main thrust of its research efforts. NASA has noted that individual companies have R&D programs devoted primarily to improving production capability with some effort to improve safety and anti-pollution equipment and methods included.

The Solicitor's Office has advised that there is legal authority to enter contracts for scientific or technological research into any aspect of problems related to Interior Department programs (42 USC § 1900), but there is no authority to require OCS operators to conduct R&D. They further advise that a joint Government-Industry R&D program would be a possibility, but would be more complex than a program operated by the USGS alone.

WORK GROUP RECOMMENDATION NO. 4

a. The USGS, in cooperation with the API, should establish a program to encourage and promote research and development in safety and anti-pollution equipment and systems. Current and completed research and development should be taken into account in the determination of specific needs. Such needs should be communicated to industry through API. For those needs where there is no response from industry, or the response is unsatisfactory, the USGS should contract for the required work. (See also Recommendation No. 8a.)

b. With specific reference to the NAE recommendations, the Work Group recommends:

   (1) The promotion of industry consensus standards should be effected through a cooperative arrangement with API (see Work Group Recommendation No. 5).

   (2) Requests should be made to NOAA, USCG, and EPA to sponsor programs to study the effects of various amounts of crude oil intrusion into the marine environment, taking into account site variables.

   (3) The recommendation to undertake quantitative studies of the effectiveness of methods for cleaning up oil from the marine environment should be referred to the U. S. Coast Guard.

   (4) The development and testing of damage-limiting and fail-safe systems in the area of damage control, fire-fighting, and well control should be an item for follow-up under the cooperative arrangement with API.

IMPLEMENTATION ACTION REQUIRED

Arrangements have been made with API for the recommended cooperative effort and the desired programs are underway with personnel from the Conservation Division participating.

EPA, NOAA, and the USCG have been requested to respond to the NAE recommendations. Their replies were favorable and pointed out the various pertinent activities in which they are already engaged.

5. STANDARDS AND SPECIFICATIONS

ECOMMENDATIONS OF STUDIES

NASA--That USGS seek API cooperation in establishing a committee to function under USGS guidance for the purpose of determining specific needs, and to write, review and approve standards/specifications for safety and anti-pollution equipment. The committee must function under the guidance of USGS.

That specifications developed by the committee contain requirements for a basic quality control system and, where equipment is to be used in a deleterious environment, an environmental test program. The committee should use, as a quality system guideline, the quality control provisions of the Bureau of Mines specification covering fuses for trailing cables used in coal mines, and in NASA Publication NPC 200-3, "Inspection System Provisions for Suppliers of Space Materials, Parts, Components and Services".

That the USGS, through OCS Orders, require the use of approved standards/specifications.

As an alternate recommendation, if the USGS cannot obtain API participation, it is recommended that USGS establish a committee, comprised of appropriate members from the industry, for the purpose of developing these standards/specifications for equipment and methods used in OCS operations.

NAE --The U.S. Government should encourage and support the development of a comprehensive system of industry consensus standards and should make use of the resulting standards system in the regulation and inspection of the offshore industry, and make adherence to such standards a consideration in the issuance of permits.

The American National Standards Institute (ANSI) should be used jointly by government and industry to integrate the efforts of government, industry, and the professional societies for the development of industry consensus standards for personnel, equipment, and operating procedures.

U. S. Government personnel associated with offshore resource development should participate in the standards preparation procedures and there should be means of assuring that such government personnel can participate as equals.

Industry and the U. S. Government should establish a working relationship for the joint development of standards for advanced deep water technology. Industry consensus standards for completion and workover safety procedures should be developed. Special consideration should be given hazard control and damage limiting methods.

The U. S. Government should develop a policy regarding the testing of offshore equipment, including the establishment of criteria for selection of test sites for such equipment in the marine environment.

REMARKS

NASA has noted the need for the development of new and more meaningful standards. It was also noted that many standards had been written in too general terms, insufficient to adequately describe a specific situation. Although equipment quality is of the utmost concern to oil operators, no requirements have been placed on manufacturers for a quality control system. Organizations already in existence, such as the American National Standards Institute, American Petroleum Institute, American Society for Testing Materials, American Society of Mechanical Engineers, etc., are best qualified to develop the necessary standards.

WORK GROUP RECOMMENDATION NO. 5

The USGS, in cooperation with API, should identify needs for additional or more specific standards for safety and anti-pollution equipment. The standards should include performance requirements for the operational testing of the equipment in the marine environment. Arrangements should be made with ANSI for the development of needed standards. API, ASTM, ASME, and other organizations should be requested to prepare proposed standards as appropriate, with USGS participation. Standards adopted by the USGS should be published and incorporated in OCS Orders. (See also Work Group Recommendation No. 4.)

IMPLEMENTATION ACTION REQUIRED

Arrangements have been made with API for its cooperation. The program is underway with participation by personnel of the Conservation Division.

6. SYSTEMS ANALYSIS[1]

RECOMMENDATIONS OF STUDIES

NASA--1. The team recommends that USGS request identification of operations and equipment critical to safety of personnel and pollution prevention. Data to complete this "Critical Items List" could be derived from two sources. One, from compilation of accident history and problem/failure reports, is the topic of another recommendation. The second source could result from analysis of the systems utilized to perform a given function. Two types of design/system analysis most commonly used in industry today are the Failure Mode, Effect Analysis (FMEA) and the Hazard Analysis (HA).

2. The USGS Gulf Coast Regional Office should be authorized to implement the proposed "design review" group.

3. The region should require submission from offshore operators a list of critical operations to be performed during drilling at time of permit request. List of critical systems should also be obtained at the time of well completion, and appropriate reviews conducted with the operator.

4. The requirement for submission of complete Hazard Analysis should be phased into system starting with new work, with time limits on existing wells.

5. The analysis group should work with operators to eliminate (reduce) hazardous operations by recommending redesign of hardware or operations.

6. Inspection criteria should be revised to include any additional critical equipment identified by Hazard Analysis.

LMS --1. Systematic procedures should be established to identify potential hazards associated with various OCS operations and provide risk assessments.

2. Design specifications for a safety program to be implemented by industry as a means of further reducing risk of accidents and losses on the OCS. The specifications should emphasize (1) the early identification of hazards, preferably in the

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[1] "Hazards Analysis" is the term used in the NASA report. "Systems Analysis" is substituted herein because it is broader and more descriptive of what actually is desired in the Work Group's recommendation.

design or planning stage of an operation and (2) the explicit statement of assumed risks and losses associated with the operation. Such statements and hazard analyses should eventually be part of applications for new platforms and associated production equipment. As part of the first phase of the safety program, each operator should be required to submit a general safety plan following Survey-defined specifications.

REMARKS

In order to evaluate Hazards Analysis and Failure Mode and Effects Analysis procedures more fully, the USGS contracted for such analyses of actual offshore drilling and producing operations. Two separate contracts were completed, one by the General Electric Corporation and the other with the Southwest Research Institute. The results are now being studied.

WORK GROUP RECOMMENDATION NO. 6

The USGS should require lessees to submit a systems analysis prior to granting approval for platforms, pipelines, drilling operations, and production operations. Operators should provide with each analysis, an identification of operations and equipment critical to safety of personnel and pollution prevention. The latter information should be incorporated into a "Critical Items List". A phased program requiring systems analysis on existing platforms and pipelines should also be developed.

IMPLEMENTATION ACTION REQUIRED

Implementation of the recommendation will require study of the findings of the recently completed contracts for hazards analysis. Assuming satisfactory results, the requirements for systems analysis should be incorporated in OCS Orders and the necessary staffing for review of analyses should be developed by the Conservation Division. The reorganization of the Conservation Division provides for an operational unit to accomplish this work.

7. ENGINEERING DOCUMENTATION

RECOMMENDATIONS OF STUDIES

NASA--*It is recommended that USGS require that certain minimum engineering documentation be available at the operator's lowest level onshore engineering office. This recommendation is made in pursuit of the preceding recommendation and others contained in this report, as well as the USGS stated objectives of reviewing process equipment designs more closely. The following list is recommended as minimum requirements:*

1. *Structural layout and details.*
2. *Piping runs.*
3. *Schematic diagrams (mechanical and electrical).*
4. *Engineering parts list (complete to valve and power supply level, including part number, name and manufacturer).*
5. *Specifications for all actively functioning components.*

REMARKS

The engineering documentation of some platform systems is incomplete, and where such documentation exists, it is not always readily available to operating personnel. The availability of complete documentation at the working level is essential for immediate analysis of problems or malfunctions that could lead to accidents.

WORK GROUP RECOMMENDATION NO. 7

OCS Orders should include requirements for certain minimum engineering documentation such as wiring diagrams, structural layouts, piping layouts, etc., to be readily available at the operator's lowest level onshore engineering office, with copies to the USGS. A Conservation Division task force should identify which documentation is required.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should organize a task force to identify the required documentation, consult with operator groups to determine that particular items can be provided meaningfully, and include appropriate requirements in OCS Orders.

8. WEAROUT PREVENTION

RECOMMENDATIONS OF STUDIES

NASA--1. *Development of a reliable sand erosion probe under USGS sponsorship (including a specification).*

2. *USGS revision of OCS No. 8 specifying method of implementation of sand erosion probe.*

3. *Requirement for rigorous test and inspection (X-Ray/sonic) of wells upon sand detection.*

At a later date, when data on failed equipment are available, an evaluation of the necessary inspection frequency and/or periodic replacement of selected safety equipment should be undertaken.

REMARKS

Sand erosion is a major cause of failure of safety equipment on wells producing sand. Although some research toward development of reliable sand erosion detectors is underway, this effort should be accelerated.

WORK GROUP RECOMMENDATION NO. 8

a. Include the development of a reliable sand erosion detector in the research and development program (see Recommendation No. 4).

b. Develop rigorous test and inspection procedures for detection and control of sand erosion (see Recommendation No. 12).

c. Using data from a failure reporting and corrective action system and other sources, specify the requirements for the frequency of inspection and the frequency of replacement for equipment susceptible to failure, and include them in OCS Orders.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should incorporate the requirement of Recommendation No. 8a in the Research and Development program, and those of Recommendation No. 8b and No. 8c in its Inspection Procedures program. OCS Orders should be revised accordingly.

9. TRAINING AND CERTIFICATION

RECOMMENDATIONS OF STUDIES

NASA--*It is recommended that USGS require, through revision or addition of OCS Orders, that:*

1. *Operators develop methods to ensure that company or contract personnel performing inspection and test of safety or anti-pollution equipment are properly trained in USGS requirements, the equipment functions, test methods, etc., prior to performing these services and that training is periodically updated as equipment is modified or new types of equipment are utilized. Operator or outside-source certification of personnel following demonstration of skill should be required.*

2. *Operators provide USGS with a description of the methods to be employed in accomplishing the above, and that these methods be approved in advance by USGS.*

NAE --*Since operator training programs are essential to safety in offshore resource development, the U. S. Government should:*

Actively encourage and support such training programs; including the objective of safe and reliable operation, installation, maintenance, and repair of equipment systems and components;

Sponsor industry-government standardization of training criteria;

Give weighted consideration to the existence and quality of job qualification requirements and corresponding personnel training in permit procedures;

Ensure the participation of U. S. Government personnel involved in standard setting, regulation and inspection or permit procedures in such training programs.

REMARKS

A considerable amount of vocational training and some safety training is already accomplished under the auspices of the Committee on Vocational Training of the Division of Production of API through courses given in various colleges and universities in the Gulf Coast area. The International Association of Drilling Contractors also trains drilling personnel, and a considerable amount of training is accomplished by the individual companies.

A Solicitor's opinion on legal authority for the USGS to require operators by regulation or OCS Order to develop and submit for approval programs for the training and certification of company personnel was answered on April 27, 1972, as follows: "In order to implement such a program, it is our opinion that Geological Survey must first set standards to be met by the companies for training and certification of personnel in safety and pollution control. Any course of study or training program sufficient to meet these standards should then be approved by Geological Survey. Companies should be free to establish their own training programs or send their personnel to an approved course".

WORK GROUP RECOMMENDATION NO. 9

a. The USGS, working with industry through API, should set standards and requirements for training of personnel, to include, but not be limited to, the following:

(1) A requirement for minimum training in safety and pollution prevention and control for all company and contractor personnel, including identification and proper use of safety equipment, emergency procedures, and first aid.

(2) A requirement that appropriate company and contractor field personnel be briefed on USGS regulations and orders.

Standards and requirements for such training should be specified in OCS Orders and a certification of compliance should become a prerequisite for certain permits and operational work. Appropriate credit should be given for pertinent experience.

b. USGS field supervisory personnel and inspectors should be required to participate in training courses appropriate to their responsibilities.

IMPLEMENTATION ACTION REQUIRED

Arrangement have been made with API for a joint effort to develop the necessary standards and specifications for training of industry personnel. The Conservation Division should pursue this effort and revise OCS Orders accordingly.

Requirements for appropriate training of USGS personnel should be included in the Division Manual.

The Conservation Division should arrange for briefing programs on USGS regulations and orders.

10. MOTIVATION PROGRAM

RECOMMENDATIONS OF STUDIES

NASA--It is recommended that USGS initiate an OCS-wide safety and anti-pollution motivation program. Such a program could be effective in terms of obtaining industry response and favorable publicity.

A program consisting of at least the following elements is suggested.

1. Visual aid package consisting of dramatic evidence of the results of carelessness and human error (pictures of platform fires, etc.) accompanied by analysis of typical events leading to accidents and pollution.

2. Periodic review of accident (safety and pollution) records, from available statistics, with appropriate awards for top performance. The awards should be public ceremonies with maximum possible publicity.

The government program could be put together by an outside company specializing in the field, but should be conducted by USGS.

Additional elements recommended to be implemented by offshore operating companies, with some USGS participation, are:

Safety training for all field personnel to include identification and proper use of all safety equipment. Review of all emergency procedures with periodic drills. Instructions concerning daily operations to avoid pollution and minimize hazards.

Periodic review of accident and pollution history to field employee level with recognition for good performance. Recognition would assist in obtaining cooperation for better reports of incidents.

Employee suggestion program regarding safety improvements for both equipment and operations. Again, a recognition system is recommended for accepted suggestions.

REMARKS

The Work Group feels that safety and anti-pollution motivation programs would be more effective if sponsored by industry, albeit the USGS should encourage such programs and participate as appropriate.

WORK GROUP RECOMMENDATION NO. 10

The USGS should ask API to take the lead in promoting safety and anti-pollution motivation programs for all personnel involved in offshore operations. API should be encouraged to obtain descriptions of the various motivation ideas and programs now practiced by several companies and publish the best in a brochure for others to consider for adoption.

IMPLEMENTATION ACTION REQUIRED

Arrangements have been made with API to assume leadership in motivation programs, encourage such programs throughout industry, and participate where appropriate. The Conservation Division should ist API in this effort.

11. LEASE MANAGEMENT PROGRAM

RECOMMENDATIONS OF STUDIES

NASA--*It is recommended that USGS regional office extend the current effort by staffing, at the earliest possible time, with personnel experienced in quality management and capable of developing, documenting and assisting the Regional Supervisor in implementing this type program. As a minimum, this program should contain the following information:*

1. *An organization chart*
2. *Functional statement for each section, district and unit*
3. *List of reports required of each section, district, and unit*
4. *Personnel training records*
5. *Detailed procedures outlining the functions to be performed by USGS personnel at both the district and regional levels*
6. *Assignment and frequency of inspection functions*
7. *List depicting areas to be controlled in performing inspection functions*
8. *Guideline procedures covering inspection and/or tests to be witnessed by USGS district personnel*
9. *Waiver/departure procedure*

It is recommended that NASA documents NPC 200-1A, "Quality Assurance Provisions for Government Agencies", and NHB 5330.7, "Management of Government Quality Assurance Functions for Supplier Operations", be used as guidelines.

USGS should require that all data generated from this planned quality effort be assembled at the regional and Washington offices to be analyzed and evaluated to determine the effectiveness of the district operations.

LMS --*The major elements of the OCS Lease Management Program, the Production Program and the Revenue Program need to be coordinated and directed to avoid conflicts over available resources.*

1. *Designate an OCS Lease Management Program Coordinator.*
2. *The Survey should hold a formal annual review of the performance of the program components.*
3. *Survey management should delineate specific operational policies for both programs.*
4. *The Survey should encourage personnel, especially field technicians, to participate in industry training programs.*
5. *A paperwork management study should be conducted in order to streamline procedures for processing documents related to oil and gas operations.*
6. *All routine procedures, decision rules, policies, and operating criteria pertaining to OCS operations should be documented in a set of Branch of Oil and Gas Operations' Manuals.*

REMARKS

Staffing for quality control management capability as recommended by NASA should be provided. These functions can and should be performed by the Operations Analysis Unit in the Conservation Division's Metairie Office when it is adequately staffed. This Unit as presently constituted includes groups with accident investigation, design review, orders and field rules, and pollution control functions.

The activities at the field level involved in the OCS lease management program are so diversified and time consuming that adequate means of coordinating them is essential. These functions, however, are the assigned responsibility of the Manager, the Supervisor, his Deputy, and the heads of the Sections, Units, and Groups now existing within the organizational structure. The Supervisor and his Deputy have the direct overall responsibility for coordination of the entire program and under a proper line-staff organizational structure it would not be appropriate to delegate this responsibility to a "Program Coordinator". Additionally, the coordination of all activities should improve when the positions under the Conservation Division reorganization plan are filled and fully operational. However, if assistance in coordinating program activities is needed, such assistance should be added to the staff.

Also, the Division's reorganization plan, when fully implemented, should provide adequate coordination of the Lease Management Program at the Division headquarters level.

WORK GROUP RECOMMENDATION NO. 11

a. The NASA recommendations listed above should be implemented to provide the needed quality management capability. Most of the items given as a minimum for the program plan are in existence, but they need to be reviewed, updated, consolidated, and systematically documented.

b. The LMS recommendations listed above should also be implemented, with the exception of item 1. Instead of an OCS Lease Management Program Coordinator, necessary staff capability should be added for program coordination.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should add personnel to implement these recommendations.

The Director's Office should develop the guidelines for a formal annual review and prepare the recommended operational policies.

A contract will probably be required for the paperwork management study.

The recommended operations manuals should be developed by the Conservation Division as soon as possible.

12. INSPECTION PROCEDURES

RECOMMENDATIONS OF STUDIES

NASA--a. The data processing equipment, that the team (LMS study team) was advised is being considered for location in the Regional Office, should be installed at the earliest possible time.

b. The presently used Potential Incidence of Non-Compliance (PINC) list should be modified to separate the gathering of descriptive information (e.g., number of wells/platforms) from compliance information (e.g., satisfactory operation of check valves).

c. A method should be established to ensure that compliance characteristics of the PINC list are maintained current as OCS Orders are revised or added.

d. Conservation Division should devise a "best method" of adapting study techniques to the needs of Region operations. An operating procedure should then be developed, and implemented as soon as possible, in order to provide uniform guidance to all concerned personnel. The procedure should include the use to be made of information generated by District, Region, and Headquarters.

e. The procedures referenced above should be integrated into the overall OCS Management Program Plan.

LMS --1. Adopt the inspection techniques and methodology developed and utilized in the course of this study.

2. Expand the scope of the inspections to include other production operations as they are specified in conjunction with the hazard review activity and as new OCS Orders are written.

3. Continue the review and analysis of inspection results in order--

a. to modify inspection strategies and to allocate resources in response to changes in the level of company activity and compliance;

b. *to advise the Offshore Operators Subcommittee on Safety of the inspection results.*

4. *Augment the existing enforcement authority with the addition of required fixed periods of shut-in time for specific items of noncompliance or combinations of items.*

5. *On a periodic basis, perhaps monthly, inform upper management of actions taken against their company.*

NAE --*Routine inspection procedures in the offshore industry should be carried out by the specific companies involved for compliance with industry consenus standards. U. S. Government inspections should be confined to spot-checking to ascertain compliance to regulations.*

REMARKS

USGS inspection procedures have been criticized for lack of uniformity among inspectors in the interpretation and application of OCS Orders. It is important that uniform practices be adopted.

LMS Recommendation 4 advocates that required fixed periods of shut-in time for specific items of noncompliance or combinations of items be added to existing enforcement authority. In response to an inquiry the Solicitor's Office stated, "The question to be asked is whether a particular regulation is designed to punish or whether it is germane to the regulatory function.... Thus, a period of shut-in which is necessary to carry out a legitimate regulatory function is permissible; however, if it is designed strictly for punishment it is not permissible, and new legislation would be required".

While it might be argued that such a shut-in would be designed as a deterrent to a recurrence of the violation, it is difficult to consider the shut-in itself anything other than a punitive action.

A further aspect is that while such a shut-in might punish the company by a temporary loss or deferment of income, the public would, likewise, have a deferment of royalty income and would suffer a loss of availability of fuel.

WORK GROUP RECOMMENDATION NO. 12

a. The USGS should incorporate into its inspection program all of the NASA recommendations (a. through e. above) and LMS recommendations 1, 2, 3, and 5 above. Punitive fixed-period shut-ins (LMS recommendation 4 above) are not permissible under existing legislation, nor are they considered advisable.

b. OCS Orders should include requirements for lessees to conduct inspections on a scheduled basis and report the results in a specified format to the USGS.

c. The USGS should explore the feasibility of third-party inspections as an alternative or supplement to lessee inspections.

d. The PINC system of inspection should be periodically reviewed to determine how it can be modified and improved.

e. The USGS should formalize inspection strategies and policies, including optimum frequencies of inspections, and emphasize improvement of methods for evaluating inspection results.

f. The USGS should continue to evaluate procedure for inspection and enforcement to insure the application of rigorous and uniform practices in light of new requirements and past experiences.

IMPLEMENTATION ACTION REQUIRED

While some of the recommendations have already been implemented, the Conservation Division should take the necessary steps to require standardized inspections by lessees.

They should also determine the feasibility of third-party inspections and recommend to the Director appropriate follow-up actions.

Systematic review by the Conservation Division of inspection methods and strategies should be continued. Procedures should be developed for rigorous and uniform application. Inspectors should be instructed accordingly.

Attainable inspection frequency schedules should be developed. Wherein these are less than the optimum, requirements for additional required capacity should be identified.

RECOMMENDATIONS OF STUDIES

NASA--In order to remain abreast of the ever-changing needs, the following recommendation is made: The USGS Regional Office should organize an OCS Order development and implementation function. This function, technical in nature, involves many hours of research, investigation, and discussion, and should be assigned to a small committee of qualified people selected by the Supervisor. This committee should:

1. Schedule meetings periodically to review current needs and evaluate existing Orders.
2. Meet with USGS Region management to determine their overall reaction to the proposed order and/or change.
3. Schedule meetings with the Offshore Operators Committee and/or subcommittee and discuss the change and the impact it will have on the operators and other companies operating in the OCS and document their comments and/or suggestions.
4. Schedule meetings with the USGS District engineers and chief technicians, discuss the proposed changes and document their comments.
5. If needed, consult with or solicit advice from field officials of other Government agencies and document their comments.
6. Assemble and consolidate the comments into a report for USGS Region management review and evaluation.
7. Coordinate for approval with the Washington level.
8. After the new Order and/or change has been agreed to by all concerned, develop the final draft to submit to Washington for signature.
9. After the Order is approved, serve in an advisory and assistance capacity to USGS management in assuring that concerned USGS and operator personnel thoroughly understand requirements prior to implementation and during implementation.

NAE --*In order to avoid inhibition of technical development and to take maximum advantage of advances made in equipment and methodology, the U. S. Government policy should be to establish regulations in terms of the objectives to be achieved and not in terms of specific methods of achieving them.*

In permit procedures, there should be continuation and refinement of the current practice of requiring submission of plans of applicants in terms of equipment and including personnel qualification and training procedures which will be used to control hazards. The government should continue to make granting and continuance of permits contingent upon adherence to regulation and submitted plans.

Regulations established for the control of offshore oil operations should take into account on a continuing basis the results of the analysis recommended above, as well as consideration of the natural environmental hazards (such as hurricanes, earthquakes, or large waves, and the state of the art of working in the marine environment).*

REMARKS

The development of OCS Orders is of utmost importance in achieving and maintaining safety and pollution control in OCS operations. More formalized organization and procedures are needed to develop new orders and to revise existing orders as new and improved technology and operating procedures are developed.

WORK GROUP RECOMMENDATION NO. 13

a. Formalized procedures of the type outlined in the NASA recommendation should be established for development and revision of OCS Orders.

b. In general, OCS Orders should specify the objectives to be achieved, with standards for achievement included by reference.

c. The Work Group agrees with the NAE recommendations that 1.) there should be continuation and refinement of the current practice of requiring submission of plans of applicants in terms of equipment and including personnel qualifications and training procedures; and 2.) that regulations should take into account on a continuing basis the results of the analysis of information resulting from accident evaluation, as well as consideration of natural environmental hazards.

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* Information resulting from accident evaluation

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should prepare written procedures outlining the step-by-step actions to be followed in the formulation of OCS Orders for all areas, in keeping with the NASA and NAE recommendations.

14. STANDARDIZATION OF FORMS

RECOMMENDATIONS OF STUDIES

NASA--*It is recommended that the USGS revise the Pollution Report form, presently being utilized in the District offices, and require its use by the operators for those spills presently requiring written confirmation. The form should include as a minimum the following:*

a. *More detailed information, especially in the area of cause and corrective action. For example, if equipment malfunction is the cause, the reason should be recorded in detail.*

b. *The "corrective action taken" remarks should include, in detail, the repair, if any, that was accomplished to correct the immediate problem.*

c. *Information should be provided as to action taken to prevent recurrence.*

REMARKS

A revised Pollution Report form is needed to derive necessary information for corrective actions.

WORK GROUP RECOMMENDATION NO. 14

The Work Group agrees with the NASA recommendation above.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should revise the form and require its use.

15. SAFETY AND ADVISORY COMMITTEES

RECOMMENDATIONS OF STUDIES

LMS --1. *Establish Offshore Operators Subcommittee on Safety--Subcommittee and the Survey should periodically review the performance of the Safety Program and exchange information on potential hazards and review program specifications.*

2. *A hazard review committee should periodically review reports of accidents, unusual operating conditions, equipment malfunctions, and inspection results, assess the adequacy of the current OCS Orders, and recommend changes in regulations or procedures which would reduce risks of accidents and associated losses to both industry and government.*

OTHER--*The Director, USGS, recommended a review committee be established on safety of OCS petroleum operations to serve as an independent audit of the effectiveness of USGS operations and procedures.*

REMARKS

The recommended committees would serve to focus attention on safety and anti-pollution problems, and apply the collective expertise of several disciplines to provide solutions. A review committee would also serve as an independent audit of USGS OCS policies and operations.

As a result of the Work Group's suggestion, subcommittees on safety under the Offshore Operators Committee and the Western Oil and Gas Association have already been established. These subcommittees can 1.) review proposed changes or additions to orders and regulations, 2.) analyze industrial-type accidents that occur during drilling and producing operations, including pipeline operations, workovers, installing platforms, and related activities, 3.) collect statistics on industrial-type accidents and their causes, and 4.) promote and review the results of systems analyses.

After consideration of alternate ways to establish a review committee, arrangements were made for the committee to be established under the auspices of Marine Board, National Academy of Engineering.

It is expected to be established in July 1973 with the following objectives:

- To provide advice on the policies and procedures of the USGS in fulfillment of its regulatory responsibilities for petroleum and gas operations in federal offshore areas related to safety, pollution control, and environmental protection.
- Review, on an advisory basis, regulations, Outer Continental Shelf Orders, field rules, and the conduct of operations.
- Prepare recommendations on the design of safety procedures and systems, and related programs.
- When requested, review significant events and prepare recommendations for corrective measures.
- To keep the public informed of its findings.

WORK GROUP RECOMMENDATION NO. 15

a. Encourage the Offshore Operators Committee (OOC), as well as the Western Oil and Gas Association (WOGA), to establish a committee on safety. This committee can serve as a vehicle for communication between the operators and the Survey in discussions of general problems that arise.

b. Establish a Systems Review Committee in each area with OCS operations, to be composed of key USGS field personnel. This committee should meet regularly to review accidents, unusual conditions, equipment failures, inspection results, and the adequacy of OCS Orders, and recommend appropriate changes in regulations, orders, and procedures. Reports of findings and recommendations should be submitted in writing to the Supervisor, with copies, through channels, to the Director, USGS.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should communicate with the safety committees of OOC and WOGA to maximize their effectiveness.

The Systems Review Committees should be established by the Conservation Division.

The Director, USGS, should propose items to the review committee for consideration. These would, of course, be additional to items which the committee would determine to consider on its own.

APPENDIX

Identification of Study Reports

1. "Applicability of NASA Contract Quality Management and Failure Mode Effect Analysis Procedures to the USGS Outer Continental Shelf Oil and Gas Lease Management Program," November 1971.

Members:

Morris K. Dyer, NASA -- Marshall Space Flight Center
Dewey G. Little, NASA -- Mississippi Test Facility
Earl G. Hoard, NASA -- Marshall Space Flight Center
Alfred C. Taylor, NASA -- Michoud Assembly Facility
Rayford Campbell, NASA -- Michoud Assembly Facility

This report, prepared for the U.S. Geological Survey by a team of National Aeronautics and Space Administration specialists, examines the feasibility of applying to offshore oil and gas operations advanced engineering techniques designed to increase the reliability of safety and anti-pollution equipment, and includes several recommendations. The study period was three months.

2. "Outer Continental Shelf Lease Management Study," May 1972.

Members (USGS):

N. C. Matalas, Project Chief
E. R. Close
Thomas Maddock, III
D. W. Moody
H. E. Robinson
J. R. Slack
T. D. Steele

Part-time Consultants (USGS):

D. R. Dawdy
B. B. Jackson
I. C. James, II

This is a report of a study conducted by the Systems Laboratory Group, Water Resources Division, U.S. Geological Survey. The study was proposed by OMB and authorized by the Director, U.S. Geological Survey, in August 1970. The report describes Survey's Outer Continental Shelf Lease Management Program and sets forth recommendations for increasing the effectiveness of the program in achieving the objectives of safety and pollution prevention.

3. "Outer Continental Shelf Resource Development Safety: A Review of Technology and Regulation for the Systematic Minimization of Environmental Intrusion from Petroleum Products," December 1972.

Members (Panel of the Marine Board, NAE):

George F. Mechlin, Chairman -- Westinghouse Electric Corp.
Claude R. Hocott -- Esso Production Research Company
Bill J. Livesay -- University of Tulsa
Richard C. Miller -- Oceanographic Service, Inc.
J. Jamison Moore -- Atlantis Scientific
William B. Rand -- Submarex Corp. (Ret.)
Willard F. Searle, Jr. -- Consulting Ocean Engineers (USN, Ret.)
Harvey J. Smith, Jr. -- Lockheed Missiles and Space Co.

U.S. Government Liaison Representatives:

Keith B. Schumacher -- U.S. Coast Guard
Eugene W. Standley -- Department of the Interior

This is a report of a special study on operational safety in offshore resources development conducted by a panel of experts convened by the Marine Board, National Academy of Engineering, at the request of the Department of the Interior. The panel met in ten working sessions from May 1971 to August 1972. The report contains numerous recommendations.

APPENDIX 22

AN EVALUATION OF "ENERGY UNDER THE OCEANS", A REPORT OF STUDY CONDUCTED BY THE TECHNOLOGY ASSESSMENT GROUP, SCIENCE AND PUBLIC POLICY PROGRAM, THE UNIVERSITY OF OKLAHOMA, AUGUST 1973[1]

By W. A. Radlinski, Associate Director
U. S. Geological Survey

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[1] Prepared for the NSF-RANN Energy, Environment, and Productivity Symposium, November 19, 1973, Washington, D.C..

The technology assessment of Outer Continental Shelf (OCS) oil and gas operations made by a research team under the aegis of the Science and Public Policy Program, University of Oklahoma, is of special significance to the U. S. Geological Survey (USGS). We have the responsibility for the issuance of exploration permits and the supervision of operations authorized by leases on the OCS. And, it is our job to see that this work is done in accordance with the law--safely, without damage to the environment, and in keeping with optimum conservation practices.

The Survey's responsibility involves the management of over 1100 leases and nearly 2000 OCS platforms in the Gulf and 5 in the Santa Barbara Channel. These include over 6,200 wells and 10,000 well completions. Over 800 requests for permits to drill were processed in the past year. Platforms in the Gulf are as far as 98 miles from shore and are in water depths to 373 feet. The area of drilling and producing operations covers approximately 40,000 square miles. In the Santa Barbara Channel the platforms are about six miles from shore and are in waters up to 191 feet.

We also collect royalties from production at the rate of 16 2/3%. Last fiscal year this amounted to $360 million. Production in Fiscal Year 1973 amounted to 446 million barrels of crude oil and natural gas liquids, and 3 trillion cubic feet of marketed gas, with a total value of over $2 billion.

Accident reduction, pollution control, and environmental protection involve a number of factors, each of which contribute to an overall strategy These include:

- o Stringent regulations insuring (but not limited to)
  - good systems designs and construction,
  - redundant safety systems,
  - training of personnel,
  - accident and equipment failure reporting,
  - and corrective action procedures.

There are currently 12 OCS Orders covering the Gulf of Mexico area and 10 for the Pacific Area (Santa Barbara Channel), the only two areas where OCS operations are now being conducted.

Other elements of our strategy are:

- o An effective inspection program
- o Safety motivation of operators and employees
- o Research and development
- o Third-party review of our policies and procedures
- o Environmental assessments.

It is with these elements in mind, and with regard for problems of the future that can result from an acceleration of lease sales into new areas, deeper waters, and different environments, that I comment now on the Oklahoma report.

Overall it's a very good report. We welcome it at the Geological Survey and we intend to respond to each of the applicable recommendations.

In fact, we have already responded to many of them as a result of implementation plans we developed in response to recommendations of three earlier reports--one by a study team from NASA, another an in-house study by a team of USGS systems analysts, and the third by a panel of the Marine Board, National Academy of Engineering. A report of these plans is available from the USGS.

All four of the reports are compatible and many of the respective recommendations are the same, but the Oklahoma report goes much further than any of the other three. In-depth considerations of Government management and jurisdictions are unique to the Oklahoma study, as is its plan for OCS development. The recommendations from these sections will contribute importantly to "rational OCS policy making" and to "optimal resources development," to quote objectives from the purpose of the study.

Of the 12 recommendations under "Management of Technologies," 9 are aimed directly at the Survey and 3 at industry. Of the 22 recommendations on "General Policy and Management," 10 involve the Survey. And all of the items listed under the recommendation for "Specific Technologies" directly affect the success of our lease management responsibilities.

Referring now to the category on Management of Technologies, herewith is the status, in brief, on the 9 recommendations applicable to the Survey:

> Standards -- Standards for the critical items of equipment are being developed under a joint API-USGS committee arrangement which involves OOC and WOGA.

These will be submitted to ANSI or other appropriate standards-setting organizations for review, and included in OCS Orders by reference. Quality control procedures for manufacturers are included.

Failure Reporting -- As announced in our press release of June 14, 1973, we intend to establish a failure reporting and corrective action system. A "safety-alert" system for immediate reporting to all lessees of equipment malfunctions, accidents or near accidents is already in effect.

Review Technology -- A Review Committee under the auspices of the Marine Board, National Academy of Engineering has already been established to serve as a third-party audit of our procedures and operations and to review state-of-the-art technologies.

Personnel Training -- A joint API-USGS committee is already working at establishing curricula and training requirements for operating personnel. We are also establishing formal training requirements for our inspectors.

Industry Cooperation -- The joint API-USGS committee on training is also developing programs for safety motivation. We have already gotten a Department of Justice opinion that information exchange in the interest of safety and environmental protection is not in violation of Anti-Trust Laws.

Subsea Production Systems -- The first OCS proposal for a subsea production system (i.e., more than one well) is presented in a draft Environmental Impact Statement now being aired publicly for the development of the Santa Ynez unit in the Santa Barbara Channel.

There are, of course, some conclusions and recommendations in the report with which we do not agree, and we are aware of disagreements by others, both pro and con. But this is to be expected from a 380-page report of a study as comprehensive as this one was. Disagreements are, of course, healthy, for they prompt dialogue and help bring out the facts. But in some cases, they have been presented out of context in support of an extreme position, either to discredit the entire report or as a basis for condemnation of all OCS development. It is important to recognize the overall objective of the study--to insure that development of the OCS is optimal in a broad social sense--and to recognize that individual recommendations are made in the context of improving, not condemning, OCS development. This is the way we in the Geological Survey are viewing it, and I feel certain this was the intent of the Assessment Group.

Our reasons for not agreeing with three of the recommendations in the Management of Technologies part of the report are as follows:

Accident Investigation -- We have not established a board similar to the National Transportation Board to investigate OCS accidents. Our present practice is to have all accidents investigated by Survey personnel in accordance with fixed procedures. Major accident reports will be submitted to our Review Committee (mentioned earlier) for review. While we consider this procedure adequate for the present, we will give further consideration to the establishment of a separate board. We do intend that all reports of major accidents will be made public.

Personnel Standards -- We have not yet concluded that certification of company personnel is a viable procedure for insuring performance. Our present objectives are to establish required standards for training or experience before allowing operations to proceed. Certification, per se, involves numerous problems of establishing certification authorities, updating, employee union regulations, and State laws. We feel that training and experience standards may serve the purpose effectively.

Government R&D -- We have not established an in-house research, development, and testing program for a very practical reason--no funds. But that's not the total reason. We should have some capability for research, but we feel that the ultimate responsibility for safety and pollution prevention rests with industry. Accordingly, our approach was to establish an American Petroleum Institute (API)-USGS R&D committee to encourage industry in this activity. A list of pertinent R&D items under investigation is being completed together with a list of those items that require new or improved development. We have informed industry that in those cases where they do not respond to R&D needs, the Government will undertake the work. But even so, public funds will need to be provided.

Concerning findings of other parts of the study -- the publication of a list of "Inadequate Components," called for in the recommendation under "Specific Technologies," will be a natural result of our aforementioned failure reporting and corrective action system. Further, these results will provide information to an established research committee to identify items for research and development. The lists of components to be developed, improved, and deployed will be passed on to the R&D committee and to a Standards Committee which is currently very active. The latter committee, by the way, has already drafted detailed standards for improved downhole safety devices which are currently being reviewed. Sand probe development and standards are high on the list of priorities.

Finally, I shall comment on the "General Policy and Management" part of the report. While we agree that promotion and regulation functions should remain divided between the Bureau of Land Management (BLM) and USGS to provide a continuous checking mechanism, we do not agree that the Survey should take the lead in preparing programmatic environmental impact statements. Programmatic concerns should remain the responsibility of BLM or the Council on Environmental Quality, as is the case in the environmental assessment of the Atlantic and Gulf of Alaska OCS. We, as well as National

Oceanic and Atmospheric Administration and many others, provide the geologic, geophysical, seismic, and other environmental data and analyses that are necessary for a full environmental impact assessment. I believe this procedure complies better with the intent, if not the organizational structure, of the study recommendations. The question of sufficiency of data is, of course, a budget problem.

Concerning the matter of concentration in the USGS of all management responsibilities on the OCS, we are currently working with the Office of Pipeline Safety to specify our respective roles. We have had meetings with the Occupational Safety and Health Administration along the same lines; we are developing understandings with the Environmental Protection Agency, and we do support the Federal Power Commission in providing estimates of recoverable gas reserves.

Lastly, by a recent policy decision, we are now publishing all new and revised OCS Orders in the Federal Register for public comment.

There have been numerous studies, reports, meetings, symposia, and legal actions concerning the development of the OCS. Several are in progress and many more will come. And this is as it should be--on the one side we have a need for the vast mineral resources that lie beneath the ocean floor, and on the other side there is a grave concern over the effects that the exploitation of these resources will have on the environment and hence our future well-being. The significance of the offshore to our national well-being, especially in these times of critical energy shortages, is clear when one realizes that over 11% of the total U.S. oil production and 13% of the gas production came from the OCS in the past year;

that this production is confined to a very small portion of those OCS areas which have petroleum potential; and that discovery and development will hopefully be accelerated as a result of tripling the offerings to three one-million acre lease sales per year.

The Oklahoma report has gone a long way in identifying means of improving development in this important area, and we commend both NSF-RANN and the University of Oklahoma on the study.

APPENDIX 23

Supplement No. 1

to

REPORT OF THE WORK GROUP ON OCS SAFETY AND POLLUTION CONTROL, MAY 1973

This supplement is a response to recommendations of the report, Energy Under the Oceans, a technology assessment of Outer Continental Shelf oil and gas operations, published in November 1973, by the University of Oklahoma Press.

U. S. Geological Survey

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May 1974

CONTENTS

Section	Page
Foreword	1
I. Recommendations Over Which the USGS Has No Control	1
II. Recommendations Already Implemented or in Progress	2
III. Recommendations Calling for Modifications of Earlier Responses	4
IV. New Recommendations	11

Foreword

This supplement is a response to recommendations of the report, Energy Under the Oceans, a technology assessment of Outer Continental Shelf oil and gas operations, published in November 1973, by the University of Oklahoma Press. The report is the result of a study conducted by an interdisciplinary research team, headed by Dr. Don E. Kash and Dr. Irvin L. White, University of Oklahoma, and funded by the National Science Foundation.

Responses are made to only those recommendations which pertain to safety and pollution control and over which the U. S. Geological Survey has some control or responsibility. The Work Group which prepared this supplement consisted of the same members who prepared the May, 1973, report responding to recommendations of three earlier studies conducted at the request of the Survey--one by a team of NASA Specialists, one by a group of USGS Systems Analysts, and one by a panel of the Marine Board, National Academy of Engineering.

The Chairman reviewed the University of Oklahoma report at an NSF critique on September 7, 1973, and at an NSF-RANN Symposium on November 19, 1973. The latter review is included as an appendix.

RESPONSE TO RECOMMENDATIONS OF "ENERGY UNDER THE OCEANS"

(A Supplement to the May 1973 Report of the
Work Group on OCS Safety and Pollution Control)

U. S. Geological Survey

The report, Energy Under the Oceans,[1] contains 39 recommendations concerning oil and gas operations on the Outer Continental Shelf. In responding to these recommendations, the U. S. Geological Survey Work Group on OCS Safety and Pollution Control placed them in four categories as follows:

I. Recommendations Over Which the USGS Has No Control

II. Recommendations Already Implemented or in Progress

III. Recommendations Calling for Modifications of Earlier Responses

IV. New Recommendations

I. RECOMMENDATIONS OVER WHICH THE USGS HAS NO CONTROL

This category includes OU[2] recommendations which the USGS cannot implement because of lack of authority or responsibility, or which are specifically addressed to other organizations. No response is made to these by the Work Group. There are 25 recommendations in this category--Nos. 1-7, 9-16, 20, 21, 23-26, 29, 34, 36, and 37. Additionally, OU Recommendation No. 8 calls for a continuation of the present separation of functions and responsibilities between USGS and BLM and, therefore, requires no response from the Work Group. It further recommends a comprehensive plan for OCS development, but the increments of the plan are covered in the other OU recommendations and the applicable ones are addressed individually below.

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[1] A Technology Assessment of Outer Continental Shelf Oil and Gas Operations prepared by an interdisciplinary research team under the aegis of the Science and Public Policy Program at the University of Oklahoma, 1973, funded by the National Science Foundation.

[2] OU--University of Oklahoma

II. RECOMMENDATIONS ALREADY IMPLEMENTED OR IN PROGRESS

In the second category of OU recommendations are four (Nos. 27, 28, 30, and 35) that are nearly identical to recommendations made in earlier studies. The Work Group has already responded to these in its report of May, 1973, and implementation actions are in progress. Included are:

OU 27. *Standards. USGS should establish equipment requirements in terms of the objectives to be achieved. While these requirements should include detailed performance standards for all pieces of equipment affecting safety and environment, design specifications should not be allowed to act as a deterrent to technological development. The presently used fines and orders for suspension of operations are generally adequate. Detailed standards will require equipment suppliers to establish quality-control procedures. (Chapter VI)*

- Agree. See Work Group Recomendation No. 5 (May 1973 report).

The first project undertaken by an API Committee formed in response to this recommendation was the development of a recommended practice for design, installation, and operation of subsurface safety valve systems (API RP 14B), and specifications for subsurface safety valves (API Std. 14A). These have now been published. A facility for testing of subsurface safety valves is being constructed in Houston, Texas, and will be operated by an independent research institute. A committee is being formed to conduct quality assurance inspections of subsurface safety valve manufacturers. The manufacturers must comply with the quality assurance program as set forth in the specifications for subsurface safety valves in order to be able to use the API monogram on their valves.

Additional projects undertaken by the Committee include: recommended practice for the design, installation, and operation of offshore platform basic surface safety systems (draft standards have been issued); specifications for surface safety valves and actuators; and a recommended practice for platform piping system design. As in the case with subsurface safety valves, quality assurance programs for other equipment items will be initiated as appropriate.

The American Petroleum Institute, the American Society for Testing Materials, the American Society of Mechanical

Engineers, the National Association of Corrosion Engineers, and other similar organizations, as appropriate, will be requested to develop needed standards. USGS representatives will participate in these efforts. Standards developed by these organizations, and appropriate existing standards now referenced in OCS orders, will be submitted to the American National Standards Institute (ANSI) for development, also with USGS participation, and for ANSI approval as national voluntary consensus standards.

OU 28. *Failure Reporting. USGS should establish improved reporting and systematic analysis procedures for failures, malfunctions, and equipment defects, as well as issue appropriate notices and warnings.*

- o Agree. See Work Group Recommendations Nos. 1, 2, and 3 (May 1973 report).

  The USGS is in the process of developing a Failure Reporting and Corrective Action System with a target completion date of June 1974. A "Safety Alert" system for immediate notification of all operators of failures and accidents was established in September 1972.

OU 30. *Review Technology. USGS should appoint an independent and representative committee of experts to review state-of-the-art in OCS technologies periodically and recommend desirable changes in equipment and performance standards. (Chapter VI)*

- o Agree. See Work Group Recommendation No. 15 (May 1973 report). Such a committee was established in July 1973, under the aegis of the Marine Board of the National Academy of Engineering. Its emphasis is on technologies related to safety and pollution control.

OU 35. *Industry Cooperation. USGS should actively promote greater industry cooperation in the development of safety, accident prevention, and environmental protection technologies. Industry should be assured that cooperation in these designated areas will not be subject to anti-trust action. This could be accomplished by having the Anti-Trust Division of the Department of Justice issue guidelines for cooperative efforts or by having the Division give opinions on specific proposals. (Chapter VI)*

- o Agree. See Work Group Recommendations Nos. 4, 5, and 10 (May 1973 report). Three cooperative committees with

API were established in September 1972--Offshore Safety and Anti-Pollution Equipment Standards; Offshore Safety and Anti-Pollution Research; and offshore Safety and Anti-Pollution Training and Motivation. All are active. The Department of Justice, by letter of November 29, 1972, stated that "it would not violate the antitrust laws for the Geological Survey to disseminate lessee-filed reports relating to the breakdown of safety and anti-pollution control equipment to all lessees operating on the OCS."

III. RECOMMENDATIONS CALLING FOR MODIFICATIONS OF EARLIER RESPONSES

In the third category of OU recommendations are six (Nos. 18, 19, 31, 32, 33, and 39) that are similar to recommendations already made by the Work Group but call for some additional responses. The Work Group's responses to these are as follows:

OU 18. *OCS Orders: Coverage. All design specifications and regulations for which USGS has administrative responsibility, including those resulting from interagency agreements, should be detailed in OCS orders for each USGS area. OCS orders should be a detailed composite of the regulations and criteria under which oil and gas operations are to be carried out. Such a composite would inform both industry and the interested public of operational standards. (Chapter VI)*

OU 19. *OCS Orders: Preparation. All OCS orders should be reviewed in advance by committees representing both industry and other interested parties selected by the Chief of the Conservation Division of USGS. At present, preparation of OCS orders involves industry participation. For example, in the Gulf Coast area, proposed orders are reviewed by the Offshore Operators Committee. Broadening the range of reviewers should assure sensitivity to a wide set of social concerns at the immediate management level. Placing selection in the Conservation Division in Washington should provide access to the best informed people in organizations such as the national environmental interest groups. (Chapter VI)*

- **With respect to the OU Recommendation No. 18, the Work Group agreed with and responded to all aspects, except it did not specifically address the matter of interagency agreements. It does so in the revised recommendation given below (paragraph d.).**

With respect to OU Recommendation No. 19, the Work Group agrees that broadening the range of reviewers is desirable, and further concludes that proposed Orders should be made available to all interested organizations on an equal basis. It may be necessary during the drafting stage to consult with individuals, from industry or elsewhere, on specific aspects of proposed Orders in their capacity as individual experts on certain specialized requirements. Proposed Orders, however, should not be made available to industry or other groups prior to their publication in the Federal Register.

Accordingly, Work Group Recommendation No. 13 (May 1973 report) is revised as follows to respond to OU Recommendations 18 and 19 (additions and changes are underlined):

WORK GROUP RECOMMENDATION NO. 13 (Revised)

a. Formalized procedures of the type outlined in the NASA recommendation should be established for development and revision of OCS Orders.

b. In general, OCS Orders should specify the objectives to be achieved, with standards for achievement included by reference.

c. The Work Group agrees with the NAE recommendations that 1) there should be continuation and refinement of the current practice of requiring submission of plans of applicants in terms of equipment and including personnel qualifications and training procedures; and 2) that regulations should take into account on a continuing basis the results of the analysis of information resulting from accident evaluation, as well as consideration of natural environmental hazards.

d. All memoranda of understanding and interagency agreements concerning management of OCS petroleum activities should be made available in a single document, and appropriate references made in OCS Orders.

e. The Conservation Division should adopt the following procedures for the development of new and revised OCS Orders:

   (1) Announce in the Federal Register its intention to prepare a new or revised Order and solicit comments and recommendations.

(2) Prepare a draft of the Order and publish it in the Federal Register for comment.

Steps (1) and (2) may in some cases be concurrent.

(3) After receipt of comments, Division personnel may meet with interested organizations or consult with individual experts on the various requirements of the Order.

(4) Revise the draft Order, if appropriate, to take into account the information developed from steps (2) and (3).

(5) If the revision is extensive or significant, republish the Order in the Federal Register as a redraft for further comment. Otherwise, publish it in the Federal Register as a final Order with an effective date.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should prepare written procedures outlining the step-by-step actions to be followed in the formulation of OCS Orders for all areas and should assemble and make available all applicable memoranda of understanding and interagency agreements.

OU 31. *Government R&D. USGS should undertake an expanded research, development, and testing program as necessary to insure optimal regulation and rapid development of new equipment and procedures. So far as possible, this work should be contracted with organizations outside the R&D system of the petroleum industry. This will help to insure that USGS and OCS operators maintain continuing effective communications with other technological communities. (Chapter VI)*

OU 39. *Inadequate Components. USGS should immediately compile a list similar to the following one* (given on pages 259 and 260 of the OU report), *and each year publish a summary review of the progress achieved in correcting weaknesses. This review should continue until the indentification system previously recommended is operational. The physical technologies with weaknesses fall into three categories: need to be developed, need to be improved, and need to be deployed. (Chapter VI)*

- Concerning R&D, the thrust of the Work Group's Recommendation No. 4 (May 1973 report) was to encourage industry to conduct the necessary R&D because of its operational responsibility for safety and pollution prevention. Accordingly, the approach was to establish an API-USGS R&D Committee to encourage industry in this activity. A list of pertinent R&D projects in progress is being completed together with a list of those needs that require new or improved development. Nevertheless, the USGS should have capability for R&D development. Therefore, the Work Group further recommended that in those cases where industry does not respond to R&D needs, the USGS will contract for the required work.

  The Work Group agrees with the second part of OU's Recommendation No. 31--to contract for R&D with organizations outside the petroleum industry to insure effective communications with other technological communities--and responds to this proposal in its revised Recommendation No. 4 given below.

  With respect to OU's Recommendation No. 39, implementation of the Work Group Recommendations Nos. 1, 2c, 3, 4, and 6 (May 1973 report) will provide a basis for compiling a list of inadequate components as well as promotion of R&D for corrective actions. The Work Group did not in its earlier recommendations address the desirability of publishing an annual summary review of progress being made towards correcting the weaknesses. It agrees, however, that this should be done.

  Accordingly, to respond to OU's Recommendations Nos. 31 and 39 the Work Group revises its Recommendation No. 4 (May 1973 report) as follows (additions and changes are underlined):

  WORK GROUP RECOMMENDATION NO. 4 (Revised)

  a. The USGS, in cooperation with the API or other appropriate organizations, should establish a program to encourage and promote research and development in safety and anti-pollution equipment and systems. Current and completed research and development should be taken into account in the determination of specific needs. Such needs should be communicated to industry through API or other appropriate organizations, and issued by USGS as an annual summary report. For those needs where there is no response from industry, or the response is unsatisfactory, the USGS should contract for the required work, utilizing, when appropriate, organizations outside the usual petroleum industry R&D establishments to perform such research. (See also Recommendation No. 8a.)

b. With specific reference to the NAE recommendations, the Work Group recommends:

(1) The promotion of industry consensus standards should be effected through a cooperative arrangement with API (see Work Group Recommendation No. 5).

(2) Requests should be made to NOAA, USCG, and EPA to sponsor programs to study the effects of various amounts of crude oil intrusion into the marine environment, taking into account site variables.

(3) The recommendation to undertake quantitative studies of the effectiveness of methods for cleaning up oil from the marine environment should be referred to the U. S. Coast Guard.

(4) The development and testing of damage-limiting and fail-safe systems in the area of damage control, fire-fighting, and well control should be an item for follow-up under cooperative arrangements with API, or other appropriate organizations.

c. Industry should be encouraged to grant reasonable access to patented safety and pollution control devices and systems to offshore operators.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should identify those physical technologies and operational

methods in need of R&D, which have a significant impact on safety and pollution control, and for which industry R&D efforts are considered inadequate or lacking. As these are identified, the Division should prepare a plan for contracting with organizations outside the petroleum industry, but giving consideration to R&D work which could be carried out by the Government itself. The plan should include recommendations for the funding of such R&D work.

The Conservation Division should also establish which organizations, other than API, could be considered for assistance in the R&D efforts of the USGS, and their participation utilized when appropriate.

OU 32. *Personnel Standards. USGS should develop uniform standards and certification requirements for personnel who perform inspection and test functions. (Chapter VI)*

OU 33. *Personnel Training. USGS should develop a program to establish improved and standardized training and procedures for operating personnel. This program should utilize the expertise of organizations and individuals such as behavioral scientists who specialize in training. (Chapter VI)*

- Work Group Recommendation No. 9 (May 1973 report) does not preclude the development of standards and requirements for personnel who perform inspection and test functions. However, Recommendation No. 9 should be amended to identify this specific need. Likewise, the desirability of utilizing training specialists should be addressed. Accordingly, Work Group Recommendation No. 9 (May 1973 report) is changed as follows (additions and changes are underlined):

WORK GROUP RECOMMENDATION NO. 9 (Revised)

a. The USGS, working with industry through API, should set standards and requirements for training of personnel, to include, but not be limited to, the following:

(1) A requirement that all operator or third party personnel, who perform

inspection and test functions related to safety and pollution control, be formally trained and qualified.

(2) A requirement for minimum training in safety and pollution prevention and control for all company and contractor personnel, including identification and proper use of safety equipment, emergency procedures, and first aid.

(3) A requirement that appropriate company and contractor field personnel be briefed on USGS regulations and orders.

b. Standards and requirements for such training should be specified in OCS Orders and a certification, by the operator, of compliance should become a prerequisite for inspecting, testing, and for certain permits and operational work. A system for updating and auditing such training should be developed. Appropriate credit should be given for pertinent experience.

c. The expertise of organizations and individuals who specialize in training should be utilized in the development of standards and requirements for training.

d. USGS field supervisory and inspection personnel should be required to participate in training courses appropriate to their responsibilities.

(The "third party" inspectors referred to in a.(1) above could be someone in the employ of the operator who is not responsible for the operations he is inspecting and who reports directly to management, or someone who is an employee of an outside firm with which the operator or group of operators contract for inspection services.)

IMPLEMENTATION ACTION REQUIRED

Arrangements have been made with API for a joint effort to develop the necessary standards and specifications for training of industry personnel. The Conservation Division should pursue this effort and revise OCS Orders accordingly.

Requirements for appropriate training of USGS personnel should be included in the Division Manual.

The Conservation Division should arrange for briefing programs on USGS regulations and orders.

IV. NEW RECOMMENDATIONS

The final category of OU recommendations include three (Nos. 17, 22, and 38) that are essentially different from those considered by the Work Group. These are discussed in the text that follows.

OU 17. *USGS Management. With limited exceptions, post-lease sale management of OCS oil and gas operations should be concentrated in USGS. The objective of this concentration of management is to eliminate gaps and overlaps and establish clear-cut responsibility. Such concentration will also assure that management decisions conform to the development plan laid out in the hierachy of impact statements. Any impact statements triggered by post-lease sale activities should be the responsibility of USGS and be subsidiary to the lease sale statement. Where necessary, transfer of operational responsibility to USGS should be accomplished by inter-agency agreements. In summary, then, the USGS should continue to administer all of its present post-lease activities plus the following: (Chapter IX)*

- o The Work Group agrees that the USGS should continue to administer all of its present post-lease activities. Comments on OU Recommendations 17a. through 17d. follow.

OU 17a. *OSHA. By agreement between Labor and Interior, OCS responsibilities assigned to the Department of Labor by the Occupational Safety and Health Act (OSHA) should be administered by USGS. The standards themselves should be developed by Labor with the advice of USGS and the Department of Health, Education, and Welfare (HEW). Such an arrangement will increase the effective day-to-day administration of the OSHA standards since USGS is already equipped to inspect OCS facilities. Further, these safety* *and health concerns are intimately tied to equipment design and operational procedures that are already a USGS responsibility. As a final advantage, this approach relieves industry of an additional layer of inspectors.*

- The Work Group agrees. A draft of a Memorandum of Understanding was completed in March 1974 but questions of statutory authority and responsibility are as yet unresolved.

WORK GROUP RECOMMENDATION NO. 16

A Memorandum of Understanding between the USGS and OSHA should continue to be sought.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should continue to take the lead in negotiating a Memorandum of Understanding between OSHA and the USGS.

OU 17b. *Environmental Administration. USGS should be responsible for enforcing all environmental quality standards applicable to OCS oil and gas operations. Where necessary, agency responsibilities should be clearly defined in inter-agency agreements between Interior, Transportation, and EPA.*

- Enforcement authorities are usually assigned by statutes. However, various inspection and monitoring activities upon which enforcement actions are based can sometimes be shared or delegated. Accordingly, current efforts towards finalizing various Memoranda of Understanding to clearly define the respective functions, scope of activities and responsibilities among the agencies involved in various aspects of environmental protection on the OCS should be expedited, and the results publicized for the guidance of all concerned. The Work Group addresses specific items in this regard in its Recommendations Nos. 13 (Revised), 16, and 17 of this report.

OU 17c. *Rights-of-Way. By formal agreement between BLM and USGS, BLM should issue rights-of-way for common carrier pipelines only upon recommendation of the USGS. This will assure that coordination exists between common carrier lines and the gathering lines presently regulated by USGS. Such authority will allow USGS to insure that pipeline development conforms to the plans developed in the impact statements. Present responsibility for pipelines is fragmented, and some agencies are incapable of meeting their regulatory responsibilities.*

OU 17d. *Pipelines. By formal agreement between the Office of Pipeline Safety (OPS) and Interior, USGS should be designated as responsible for enforcing design and performance standards for offshore pipelines which are now under OPS jurisdiction. The standards, however, should be jointly formulated by OPS and USGS. USGS presently exercises such authority over gathering lines.*

- **Activities for the development of Memoranda of Understanding between USGS, BLM, and OPS in accordance with the intent of OU Recommendations 17c. and d. have been underway for some time. The principal delaying factors have been the need for reviews of the respective pipeline administering activities, including legal reviews, to clarify the statutory authorities and responsibilities of USGS, BLM, and OPS.**

  Current draft proposals of Memoranda of Understanding between USGS and BLM provide for USGS review, prior to final action by BLM, of all rights-of-way applications to install common carrier type pipelines pursuant to 43 CFR 2883. The reviews by USGS would focus on the technical aspects of OCS pipeline design, installation, maintenance and operation in accordance with appropriate regulations and standards designed for safety and environmental protection, and to avoid undue interference with other uses of the OCS and its superjacent waters. The USGS, in cooperation with BLM, will continue efforts to formulate an agreement with OPS whereby OPS safety standards developed for OCS pipelines may be enforced by the USGS.

WORK GROUP RECOMMENDATION NO. 17

a. A Memorandum of Understanding between USGS nad BLM should be developed whereby BLM approval of pipeline rights-of-way applications will require a determination by USGS of the adequacy of the application with respect to design, installation, maintenance and operation.

b. A Memorandum of Understanding between USGS, BLM, and OPS should be formulated whereby the USGS will enforce OPS safety standards, jointly developed by OPS and USGS, for OCS pipelines.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should continue efforts to formulate a Memorandum of Understanding between the USGS and BLM concerning pipeline rights-of-way and a Memorandum of Understanding between USGS, BLM, and OPS for the enforcement of safety standards for pipelines.

OU 17e. *Gas Reserves. By formal agreement between the Federal Power Commission (FPC) and Interior, USGS should be required to provide estimates of recoverable gas reserves to be served by proposed new gas lines. Attached to the estimates should be an assessment of how the line will fit into the development plan established in the impact statements. Additionally, USGS should be available to FPC for consultation on all questions concerning lines. The purpose is to assist FPC in approving new pipelines so that they conform to the development plan established in the impact statements.*

- Estimates of recoverable gas reserves to be served by proposed new gas lines are the responsibility of FPC, but the USGS has cooperated with the FPC when requested and is available for assistance and consultation.

OU 22. *Apply FWPCA to OCS. The FWPCA Amendments of 1972 should be amended specifically to apply discharge provisions to the OCS. Under this arrangement,* *EPA would establish the standards, but as recommended earlier, USGS would have enforcement responsibility. There is no apparent reason why the general principle of a separate agency to set environmental standards should not be applicable to the OCS. Such a separation provides an additional check and increased public credibility in this sensitive area. (Chapter X)*

- The OU recommendation implies that the pollutant discharge provisions of the Federal Water Pollution Control Act (FWPCA) Amendments of 1972 are not applicable to OCS lease operations. This is contrary to the memorandum opinion of January 30, 1973, of the Assistant Solicitor, International Marine Minerals, Department of the Interior. The Assistant Solicitor's opinion was that discharges of pollutants from OCS structures are subject to the National Pollutant Discharge System established by the 1972 FWPCA Amendments. The applicable paragraph of the opinion states:

> "It should be noted that the Administrator, Environmental Protection Agency, is given broad discretionary and regulatory authority in implementing and administering the provisions of this legislation. In particular, your attention is invited to section 501(b) authorizing the Administrator to utilize the officers and employees of any other agency of the United States (with the consent of the head of such agency) to assist in carrying out the purposes of the Act. In these circumstances, it is recommended that you contact appropriate EPA officials regarding the possibility of an agreement under which the expertise of Geological Survey officials would be utilized in the administration of the National Pollutant Discharge System in its application to discharges arising from OCS lease operations."

Accordingly, the USGS has initiated discussions with EPA to consider the feasibility of a Memorandum of Understanding to minimize a redundancy of efforts and to utilize the expertise of USGS field personnel in the administration of the National Pollutant Discharge System with respect to OCS lease operations.

WORK GROUP RECOMMENDATION NO. 18

- The USGS and EPA should continue to pursue their discussions leading to the joint development of discharge standards for the OCS and a Memorandum of Understanding calling for enforcement by the USGS.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should pursue efforts to develop a Memorandum of Understanding between USGS and EPA for the formulation and enforcement of pollutant discharge standards.

OU 38. *Subsea Production Systems. USGS should encourage early development and use of subsea production systems. Parallel to this, efforts should be made to formulate those specifications and regulations necessary to insure safe operation of subsea production systems. (Chapter VI)*

- Subsea production systems represent one of many relatively new and advanced systems and technologies presently under development and in limited use which, of course, should be encouraged. USGS solicits briefings and demonstrations by the developers of such systems, and provides advice on requirements and design features. Specifications and regulations necessary to insure safe operations of subsea production systems can be formulated by implementation of Work Group Recommendations Nos. 5, 6, and 13 (May 1973 report).

WORK GROUP RECOMMENDATION NO. 19

a. The USGS should make a special effort to become acquainted with all subsea production systems under development and in use.

b. Industry should be encouraged to speed up development and testing of such systems. USGS personnel should be observers of such tests.

c. If it is determined that subsea production systems are preferable from an environmental standpoint, their use should be encouraged.

d. The cooperative USGS-API committee on standards should sponsor the preparation of standards and specifications of the safety and pollution control aspects of subsea production systems at the earliest appropriate time.

e. Concurrent with development and testing, USGS should begin the preparation of OCS Orders covering the use of subsea production systems.

IMPLEMENTATION ACTION REQUIRED

The Conservation Division should actively pursue each of the items in Recommendation No. 19.

APPENDIX 24

California Oil Supply and Demand 1/ 1973 - 1985

In order to determine what effects resulting oil would have on supply and demand by 1985, if the sale takes place, certain assumptions must be made on which to base the projection, these are:

1) A decrease in annual consumer growth demand from over 7 percent in California, to the level of the Federal Energy Administration energy demand forecast level of 2.7 and 3.2 percent.

2) A decrease in current state production including federal and state OCS operations at an average of 2.5 percent per year.

3) Estimated daily federal OCS production as a result of this one sale at a maximum of 650,000 BPD by 1985. (high case)

4) No other new major oil and gas development projects undertaken in California.

The application of these premises would have the following effect thru 1985.

California Oil 2/
2.7 percent annual consumption growth
(thousands of barrels per day)

	1973	1978	1982	1985
Consumption	1715	1959	2180	2361
Production				
State & OCS	921	814	737	685
New OCS	0	45	400	650
Total	921	859	1137	1335
Shortfall	-794	-1100	-1043	-1026

1/ A more complete discussion of this topic can be found in Volume II, Section III.J.3. (Oil and Gas Supply and Demand).

California Oil 2/
3.2 percent annual consumer growth
(thousands of barrels per day)

	1973	1978	1982	1985
Consumption	1715	2008	2277	2503
Production				
State & OCS	921	814	737	685
New OCS	0	45	400	650
Total	921	859	1137	1335
	-794	-1149	-1140	-1168

2/ The maximum deviation at the high end (1985) of these two forecasts from the base case (3 percent annual growth) presented in Section III.J.3. is a + 58,000 to a - 84,000 BPD in consumption demand.

APPENDIX 25

THE CALIFORNIA COASTAL ZONE
CONSERVATION ACT OF 1972

"PROPOSITION-20"

THE CALIFORNIA COASTAL ZONE CONSERVATION ACT OF 1972
as amended by Chapters 28 and 1014 (1973)

The people of the State of California do enact as follows:

SECTION 1. Division 18 (commencing with Section 27000) is added to the Public Resources Code, to read:

DIVISION 18. CALIFORNIA COASTAL ZONE CONSERVATION COMMISSION
CHAPTER 1. GENERAL PROVISIONS AND FINDINGS AND DECLARATIONS OF POLICY

27000. This division may be cited as the California Coastal Zone Conservation Act of 1972.

27001. The people of the State of California hereby find and declare that the California coastal zone is a distinct and valuable natural resource belonging to all the people and existing as a delicately balanced ecosystem; that the permanent protection of the remaining natural and scenic resources of the coastal zone is a paramount concern to present and future residents of the state and nation; that in order to promote the public safety, health, and welfare, and to protect public and private property, wildlife, marine fisheries, and other ocean resources, and the natural environment, it is necessary to preserve the ecological balance of the coastal zone and prevent its further deterioration and destruction; that it is the policy of the state to preserve, protect, and, where possible, to restore the resources of the coastal zone for the enjoyment of the current and succeeding generations; and that to protect the coastal zone it is necessary:

(a) To study the coastal zone to determine the ecological planning principles and assumptions needed to ensure conservation of coastal zone resources.

(b) To prepare, based upon such study and in full consultation with all affected governmental agencies, private interests, and the general public, a comprehensive, coordinated, enforceable plan for the orderly, long-range conservation and management of the natural resources of the coastal zone, to be known as the California Coastal Zone Conservation Plan.

(c) To ensure that any development which occurs in the permit area during the study and planning period will be consistent with the objectives of this division.

(d) To create the California Coastal Zone Conservation Commission, and six regional coastal zone conservation commissions, to implement the provisions of this division.

CHAPTER 2. DEFINITIONS

27100. "Coastal zone" means that land and water area of the State of California from the border of the State of Oregon to the border of the Republic of Mexico, extending seaward to the outer limit of the state jurisdiction, including all islands within the jurisdiction of the state, and extending inland to the highest elevation of the nearest coastal mountain range, except that in Los Angeles, Orange, and San Diego Counties, the inland boundary of the coastal zone shall be the highest elevation of the nearest coastal mountain range or five miles from the mean high tide line, whichever is the shorter distance.

27101. "Coastal zone plan" means the California Coastal Zone Conservation Plan.

27102. (a) "Commission" means the California Coastal Zone Conservation Commission.

(b) "Regional commission" means any regional coastal zone conservation commission.

27103. "Development" means, on land, in or under water, the placement or erection of any solid material or structure; discharge or disposal of any dredged material or of any gaseous, liquid, solid, or thermal waste; grading, removing, dredging, mining, or extraction of any materials; change in the density or intensity of use of land, including, but not limited to, subdivision of land pursuant to the Subdivision Map Act and any other division of land, including lot splits; change in the intensity of use of water, ecology related thereto, or of access thereto; construction, reconstruction, demolition, or alteration of the size of any structure, including any facility of any private, public, or municipal utility, and the removal or logging of major vegetation. As used in this section, "structure" includes, but is not limited to, any building, road, pipe, flume, conduit, siphon, aqueduct, telephone line, and electrical power transmission and distribution line.

27104. "Permit area" means that portion of the coastal zone lying between the seaward limit of the jurisdiction of the state and 1,000 yards landward from the mean high tide line of the sea subject to the following provisions:

(a) The area of jurisdiction of the San Francisco Bay Conservation and Development Commission, together with all contiguous areas 2,900 feet landward thereof, and any river, stream, tributary, creek, or flood control or drainage channel which flows into such area, is excluded.

(b) If any portion of any body of water which is not subject to tidal action lies within the permit area, the body of water together with a strip of land 1,000-feet wide surrounding it shall be included; provided, however, that this subdivision does not apply to any river, stream, tributary, creek, or flood control or drainage channel when a portion of it lies within the permit area.

(c) Any urban land area which is (1) a residential area zoned, stabilized and developed to a density of four or more dwelling units per acre on or before January 1, 1972; or (2) a commercial or industrial area zoned, developed, and stabilized for such use on or before January 1, 1972, may, after public hearing, be excluded by the regional commission at the request of a city or county within which such area is located. An urban land area is "stabilized" if 80 percent of the lots are built upon to the maximum density or intensity of use permitted by the applicable zoning regulations existing on January 1, 1972.

Tidal and submerged lands, beaches, and lots immediately adjacent to the inland extent of any beach or of the mean high tide line where there is no beach shall not be excluded.

Orders granting such exclusion shall be subject to conditions which shall assure that no significant change in density, height, or nature of uses occurs.

An order granting exclusion may be revoked at any time by the regional commission, after public hearing.

(d) Each regional commission shall adopt a map delineating the precise boundaries of the permit area within 60 days after its first meeting and file a copy of such map in the office of the county clerk of each county within its region. In delineating any inland boundary of the permit area, the regional commission may adjust such boundary by moving it seaward by not more than 50 yards. Such adjustments may only be made to avoid bisecting any lot or parcel owned by the same person or to conform to identifiable physical natural or manmade features such as streets, highways, or any structures, in order to more efficiently carry out the provisions of Chapter 5 (commencing with Section 27400) of this division.

27105. "Person" includes any individual, organization, partnership, and corporation, including any utility and any agency of federal, state, and local government.

27106. "Sea" means the Pacific Ocean and all the harbors, bays, channels, estuaries, salt marshes, sloughs, and other areas subject to tidal action through a connection with the Pacific Ocean, excluding nonestuarine rivers, streams, tributaries, creeks and flood control and drainage channels.

CHAPTER 3. CREATION, MEMBERSHIP, AND POWERS OF COMMISSION AND REGIONAL COMMISSIONS

Article 1. Creation and Membership of Commissions and Regional Commissions

27200. The California Coastal Zone Conservation Commission is hereby created and shall consist of the following members:

(a) Six representatives from the regional commissions, selected by each regional commission from among its members.

(b) Six representatives of the public who shall not be members of a regional commission.

27201. The following six regional commissions are hereby created:

(a) The North Coast Regional Commission for Del Norte, Humboldt, and Mendocino Counties shall consist of the following members:

(1) One supervisor and one city councilman from each county.

(2) Six representatives of the public.

(b) The North Central Coast Regional Commission for Sonoma, Marine, and San Francisco Counties shall consist of the following members:

(1) One supervisor and one city councilman from Sonoma County and Marin County.

(2) Two supervisors of the City and County of San Francisco.

(3) One delegate to the Association of Bay Area Governments.

(4) Seven representatives of the public.

(c) The Central Coast Regional Commission for San Mateo, Santa Cruz, and Monterey Counties shall consist of the following members:

(1) One supervisor and one city councilman from each county.

(2) One delegate to the Association of Bay Area Governments.

(3) One delegate to the Association of Monterey Bay Area Governments.

(4) Eight representatives of the public.

(d) The South Central Coast Regional Commission for San Luis Obispo, Santa Barbara, and Ventura Counties shall consist of the following members:

(1) One supervisor and one city councilman from each county.

(2) Six representatives of the public.

(e) The South Coast Regional Commission for Los Angeles and Orange Counties shall consist of the following members:

(1) One supervisor from each county.

(2) One city councilman from the City of Los Angeles selected by the president of such city council.

(3) One city councilman from Los Angeles County from a city other than Los Angeles.

(4) One city councilman from Orange County.

(5) One delegate to the Southern California Association of Governments.

(6) Six representatives of the public.

(f) The San Diego Coast Regional Commission for San Diego County, shall consist of the following members:

(1) Two supervisors from San Diego County and two city councilmen from San Diego County, at least one of whom shall be from a city which lies within the permit area.

(2) One city councilman from the City of San Diego, selected by the city council of such city.

(3) One member of the San Diego Comprehensive Planning Organization.

(4) Six representatives of the public.

27202. All members of the regional commissions and public members of the commission shall be selected or appointed as follows:

(a) All supervisors, by the board of supervisors on which they sit;

(b) All city councilmen except under subsections (e) (2) and (f) (2), by the city selection committee of their respective counties;

(c) All delegates of regional agencies, by their respective agency;

(d) All public representatives, equally by the Governor, the Senate Rules Committee and the Speaker of the Assembly, provided that the extra member under (b) (4) and the extra members under (c) (4) shall be appointed by the Governor, the Senate Rules Committee and the Speaker of the Assembly respectively.

Article 2. Organization

27220. Each public member of the commission or of a regional commission shall be a person who, as a result of his training, experience, and attainments, is exceptionally well qualified to analyze and interpret environmental trends and information, to appraise resource uses in light of the policies set forth in this division, to be responsive to the scientific, social, esthetic, recreational, and cultural needs of the state. Expertise in conservation, recreation, ecological and physical sciences, planning, and education shall be represented on the commission and regional commissions.

27221. Each member of the commission and each regional commission shall be appointed or selected not later than December 31, 1972.

Each appointee of the Governor shall be subject to confirmation by the Senate.

27222. In the case of persons qualified for membership because they hold a specified office, such membership ceases when their term of office ceases. Vacancies which occur shall be filled in the same manner in which the original member was selected or appointed.

27223. Except as provided in this section, members shall serve without compensation but shall be reimbursed for the actual and necessary expenses incurred in the performance of their duties to the extent that reimbursement is not otherwise provided by another public agency. All members shall receive fifty dollars ($50) for each full day of attending meetings of the commission or of any regional commission.

27224. The commission and regional commissions shall meet no less than once a month at a place convenient to the public. Unless otherwise provided in this division, no decision on permit applications or on the adoption of the coastal zone plan or any part thereof shall be made without a prior public hearing. All meetings of the commission and each regional commission shall be open to the public. A majority affirmative vote of the total authorized membership shall be necessary to approve any action required or permitted by this division, unless otherwise provided.

27225. The first meeting of the commission shall be no later than February 15, 1973. The first meeting of the regional commissions shall be no later than February 1, 1973.

27226. The headquarters of the commission shall be in a city, county, or city and county which lies, in whole or in part, within the coastal zone.

Article 2.5. Conflicts of Interest

27230. Except as hereinafter provided none of the following persons shall appear or act, in any capacity whatsoever except as a representative of the state, or political subdivision thereof, in connection with any proceeding, hearing, application, request for ruling or other official determination, judicial or otherwise, in which the coastal zone plan, or the commission or any regional commission is involved in an official capacity:

(a) Any member or employee of the commission or regional commission;

(b) Any former member or employee of the commission or regional commission during the year following termination of such membership or employment;

(c) Any partner, employer, an employee of a member or employee of the commission or any regional commission, when the matter in issue is one which is under the official responsibility of such member or employee, or in connection with which such member or employee has acted or is scheduled to act, in any official capacity whatsoever.

27231. No member or employee of the commission or any regional commission shall participate, in any official capacity whatsoever, in any proceeding, hearing, application, request for ruling or other official determination, judicial or otherwise, in which any of the following has a financial interest: the member or employee himself; his spouse; his child; his partner; any organization in which he is then serving or has, within two years prior to his selection or appointment to or employment by such commission or regional commission, served, in the capacity of officer, director, trustee, partner, employer or employee; any organization within which he is negotiating for or has any arrangement or understanding concerning prospective partnership or employment.

27232. In any case within the coverage of Section 27230, or Section 27231 when the commission determines that in any case within the coverage of such section the financial interest involved is not substantial, the prohibitions therein contained shall not apply if the person concerned advises the commission in advance of the nature and circumstances thereof, including full public disclosure of the facts which may potentially give rise to a violation of this article, and obtains from the commission a written determination that the contemplated action will not adversely affect the integrity of the commission or any regional commission. Any determination made pursuant to this section shall require the affirmative vote of two-thirds of the members of the commission.

27233. Nothing in this article shall preclude or prevent any member of the commission or any regional commission, or any employee thereof, who is also an employee of another public agency, a county supervisor, city councilman, member of the Association of Bay Area Governments, member of the Association of Monterey Bay Associated Governments, delegate to the Southern California Association of Governments, or member of the San Diego Comprehensive Planning Organization, and who has in such designated capacity voted or acted upon a particular matter, from voting or otherwise acting upon such matter as a member of the commission or any regional commission, or employee thereof, as the case may be. Nothing in this section shall be construed to exempt any such member of the commission or any regional commission, or any employee thereof, from any other provision of this article.

27234. Any person who violates any provision of this article shall, upon conviction, and for each such offense, be subject to a fine of not more than ten thousand dollars ($10,000) or imprisonment in the state prison for not more than two years, or both.

Article 3. POWERS AND DUTIES

27240. The commission and each regional commission, may:

(a) Accept grants, contributions, and appropriations;

(b) Contract for any professional services if such work or services cannot satisfactorily be performed by its employees;

(c) Be sued and sue to obtain any remedy to restrain violations of this division. Upon request of the commission or any regional commission, the State Attorney General shall provide necessary legal representation.

(d) Adopt any regulations or take any action it deems reasonable and necessary to carry out the provisions of this division, but no regulations shall be adopted without a prior public hearing.

27241. The commission and regional commissions may request and utilize the advice and services of all federal, state, and local agencies. Upon request of a regional commission any federally recognized regional planning agency within its region shall provide staff assistance insofar as its resources permit.

27242. All elements of the California Comprehensive Ocean Area Plan, together with all staff and funds appropriated or allocated to it, shall be delivered by the Governor and shall be attached and allocated to the commission at its first meeting.

27243. The commission and each regional commission shall each elect a chairman and appoint an executive director, who shall be exempt from civil service.

CHAPTER 4. CALIFORNIA COASTAL ZONE CONSERVATION PLAN

Article 1. Generally

27300. The commission shall prepare, adopt, and submit to the Legislature for implementation the California Coastal Zone Conservation Plan.

27301. The coastal zone plan shall be based upon detailed studies of all the factos that significantly affect the coastal zone.

27302. The coastal zone plan shall be consistent with all of the following objectives:

(a) The maintenance, restoration, and enhancement of the overall quality of the coastal zone environment, including, but not limited to, its amenities and aesthetic values.

(b) The continued existence of optimum populations of all species of living organisms.

(c) The orderly, balanced utilization and preservation, consistent with sound conservation principles, of all living and nonliving coastal zone resources.

(d) Avoidance of irreversible and irretrievable commitments of coastal zone resources.

27303. The coastal zone plan shall consist of such maps, text and statements of policies and objectives as the commission determines are necessary.

27304. The plan shall contain at least the following specific components:

(a) A precise, comprehensive definition of the public interest in the coastal zone.

(b) Ecological planning principles and assumptions to be used in determining the suitability and extent of allowable development.

(c) A component which includes the following elements:

(1) A land-use element.

(2) A transportation element.

(3) A conservation element for the preservation and management of the scenic and other natural resources of the coastal zone.

(4) A public access element for maximum visual and physical use and enjoyment of the coastal zone by the public.

(5) A recreation element.

(6) A public services and facilities element for the general location, scale, and provision in the least environmentally destructive manner of public services and facilities in the coastal zone. This element shall include a power plant siting study.

(7) An ocean mineral and living resources element.

(8) A population element for the establishment of maximum desirable population densities.

(9) An educational or scientific use element.

(d) Reservations of land or water in the coastal zone for certain uses, or the prohibition of certain uses in specific areas.

(e) Recommendations for the governmental policies and powers required to implement the coastal zone plan including the organization and authority of the governmental agency or agencies which should assume permanent responsibility for its implementation.

Article 2. Planning Procedure

27320. (a) The commission shall, within six months after its first meeting, publish objectives, guidelines, and criteria for the collection of data, the conduct of studies, and the preparation of local and regional recommendations for the coastal zone plan.

(b) Each regional commission shall, in cooperation with appropriate local agencies, prepare its definitive conclusions and recommendations, including recommendations for areas that should be reserved for specific uses or within which specific uses should be prohibited, which it shall, after public hearing in each county within its region, adopt and submit to the commission no later than April 1, 1975.

(c) On or before December 1, 1975, the commission shall adopt the coastal zone plan and submit it to the Legislature for its adoption and implementation.

CHAPTER 5. INTERIM PERMIT CONTROL

Article 1. General Provisions

27400. On or after February 1, 1973, any person wishing to perform any development within the permit area shall obtain a permit authorizing such development from the regional commission and, if required by law, from any city, county, state, regional or local agency.

Except as provided in Sections 27401 and 27422, no permit shall be issued without the affirmative vote of a majority of the total authorized membership of the regional commission, or of the commission on appeal.

27401. No permit shall be issued for any of the following without the affirmative vote of two-thirds of the total authorized membership of the regional commission, or of the commission on appeal:

(a) Dredging, filling, or otherwise altering any bay, estuary, salt marsh, river mouth, slough, or lagoon.

(b) Any development which would reduce the size of any beach or other area usable for public recreation.

(c) Any development which would reduce or impose restrictions upon public access to tidal and submerged lands, beaches and the mean high tideline where there is no beach.

(d) Any development which would substantially interfere with or detract from the line of sight toward the sea from the state highway nearest the coast.

(e) Any development which would adversely affect water quality, existing areas of open water free of visible structures, existing and potential commercial and sport fisheries, or agricultural uses of land which are existing on the effective date of this division.

27402. No permit shall be issued unless the regional commission has first found, both of the following:

(a) That the development will not have any substantial adverse environmental or ecological effect.

(b) That the development is consistent with, the findings and declarations set forth in Sections 27001 and with the objectives set forth in Section 27302.

The applicant shall have the burden of proof on all issues.

27403. All permits shall be subject to reasonable terms and conditions in order to ensure:

(a) Access to publicly owned or used beaches, recreation areas, and natural reserves is increased to the maximum extent possible by appropriate dedication.

(b) Adequate and properly located public recreation areas and wildlife preserves are reserved.

(c) Provisions are made for solid and liquid waste treatment, disposition, and management which will minimize adverse effects upon coastal zone resources.

(d) Alterations to existing land forms and vegetation, and construction of structures shall cause minimum adverse effect to scenic resources and minimum danger of floods, landslides, erosion, siltation, or failure in the event of earthquake.

27404. If, prior to November 8, 1972, any city or county has issued a building permit, no person who has obtained a vested right thereunder shall be required to secure a permit from the regional commission; providing that no substantial changes may be amde in any such development, except in accordance with the provisions of this division. Any such person shall be deemed to have such vested rights if, prior to November 8, 1972, he has in good faith and in reliance upon the building permit diligently commenced construction and performed substantial work on the development and incurred substantial liabilities for work and materials necessary therefor. Expenses incurred in obtaining the enactment of an ordinance in relation to the particular development or the issuance of a permit shall not be deemed liabilities for work or material.

27405. Notwithstanding any provision in this chapter to the contrary, no permit shall be required for the following types of development:

(a) Repairs and improvements not in excess of seven thousand five hundred dollars ($7,500) to existing single-family residences; provided, that the commission shall specify by regulation those classes of development which involve a risk of adverse environmental effect and may require that a permit be obtained.

(b) Maintenance dredging of existing navigation channels or moving dredged material from such channels to a disposal area outside the permit area, pursuant to a permit from the United States Army Corps of Engineers.

(c) Repair or maintenance activities of any sort; provided, that such activities do not result in an addition to, or enlargement or expansion of, the object of such repair or maintenance activities.

Article 2. Permit Procedure

27420. (a) The commission shall prescribe the procedures for permit applications and their appeal and may require a reasonable filing fee and the reimbursement of expenses. All such fees and reimbursements collected heretofore or hereafter shall be credited to, and shall be in augmentation of, the appropriation made in Section 4 of Proposition 20 as approved by the electorate at the general election on November 7, 1972, and are hereby appropriated to the commission for the same period and for the same purposes as set forth therein.

(b) The regional commission shall give written public notice of the nature of the proposed development and of the time and place of the public hearing. Such hearing shall be set no less than 21 nor more than 90 days after the date on which the application is filed.

(c) The regional commission shall act upon an application for permit within 60 days after the conclusion of the hearing and such action shall become final after the tenth working day unless an appeal is filed within that time.

27421. Each unit of local government within the permit area shall send a duplicate of each application for a development within the permit area to the regional commission at the time such application for a local permit is filed, and shall advise the regional commission of the granting of any such permit.

27422. The commission shall provide, by regulation, for the issuance of permits by the executive directors without compliance with the procedure specified in this chapter in cases of emergency or for repairs or improvements to existing structures not in excess of twenty-five thousand dollars ($25,000) and other developments not in excess of ten thousand dollars ($10,000). Nonemergency permits shall not be effective until after reasonable public notice and adequate time for the review of such issuance has been provided. If any two members of the regional commission so request at the first meeting following the issuance of such permit, such issuance shall not be effective and instead the application shall be set for a public hearing pursuant to the provisions of Section 27420.

27423. (a) An applicant, or any person aggrieved by approval of a permit by the regional commission, may appeal to the commission.

(b) The commission may affirm, reverse, or modify the decision of the regional commission. If the commission fails to act within 60 days after notice of appeal has been filed, the regional commission's decision shall become final.

(c) The commission may decline to hear appeals that it determines raise no substantial issues. Appeals it hears shall be scheduled for a de novo public hearing and shall be decided in the same manner and by the same vote as provided for decisions by the regional commissions.

27424. Any person, including an applicant for a permit, aggrieved by the decision or action of the commission or regional commission shall have a right to judicial review of such decision or action by filing a petition for a writ of mandate in accordance with the provisions of Chapter 2, (commencing with Section 1084) of Title 1 of Part 3 of the Code of Civil Procedure, within 60 days after such decision or action has become final.

27425. Any person may maintain an action for declaratory and equitable relief to restrain violation of this division. No bond shall be required for an action under this section.

27426. Any person may maintain an action for the recovery of civil penalties provided in Sections 27500 and 27501.

27427. The provisions of this article shall be in addition to any other remedies available at law.

27428. Any person who prevails in a civil action brought to enjoin a violation of this division or to recover civil penalties shall be awarded his costs, including reasonable attorneys fees.

CHAPTER 6. PENALTIES

27500. Any person who violates any provision of this division shall be subject to a civil fine not to exceed ten thousand dollars ($10,000).

27501. In addition to any other penalties, any person who performs any development in violation of this division shall be subject to a civil fine not to exceed five hundred dollars ($500) per day for each day in which such violation persists.

CHAPTER 7. REPORTS

27600. (a) The commission shall file annual progress reports with the Governor and the Legislature not later than the fifth calendar day of the 1974 and 1975 Regular Sesseion of the Legislature, and shall file its final report containing the coastal zone plan with the Governor and the Legislature not later than the fifth calendar day of the 1976 Regular Session of the Legislature.

CHAPTER 8. TERMINATION

27650. This division shall remain in effect until the 91st day after the final adjournment of the 1976 Regular Session of the Legislature, and as of that date is repealed.

SEC. 2. Section 11528.2 is added to the Business and Professions Code, to read:

11528.2 The clerk of the governing body or the advisory agency of each city or county or city and county having jurisdiction over any part of the coastal zone as defined in Section 27100 of the Public Resources Code, shall transmit to the office of the California Coastal Zone Conservation Commission within three days after the receipt thereof, one copy of each tentative map of any subdivision located, wholly or partly, within the coastal zone and such Commission may, within 15 days thereafter, make recommendations to the appropriate local agency regarding the effect of the proposed subdivision upon the California Coastal Zone Conservation Plan. This section does not exempt any such subdivision from the permit requirements of Chapter 5 (commencing with Section 27400) of Division 18 of the Public Resources Code.

This section shall remain in effect only until the 91st day after the final adjournment of the 1976 Regular Session of the Legislature, and as of that day is repealed.

SEC. 3. If any provision of this act or the application thereof to any person or circumstances is held invalid, such invalidity shall not affect other provisions or applications of the act which can be given effect without the invalid provision or application, and to this end the provisions of this act are severable.

SEC. 4. There is hereby appropriated from the Bagley Conservation Fund to the California Coastal Zone Conservation Commission the sum of five million dollars ($5,000,000) to the extent that any moneys are available in such fund and if all or any portions thereof are not available then from the General Fund for expenditure to support the operations of the commission and regional coastal zone conservation commissions during the fiscal years of 1973 to 1976, inclusive, pursuant to the provisions of Division 18 (commencing with Section 27000) of the Public Resources Code.

SEC. 5. The Legislature may, by two-thirds of the membership concurring, amend this act in order to better achieve the objectives set forth in Sections 27001 and 27302 of the Public Resources Code.

APPENDIX 26

Characteristics Of Inorganic Metal Pollutants

The following is taken from National Academy of Sciences/National Academy of Engineering (1972).

References for this discussion have been omitted for brevity. See original sources for references.

Arsenic

Arsenic occurs in nature mostly as arsenides or pyrites. It is also found occasionally in the elemental form. Its consumption in the U.S. in 1968 amounted to 25,000 tons as AS_2O_3 (U.S. Department of the Interior, Bureau of Mines 1969).[289] Arsenic is used in the manufacture of glass, pigments, textiles, paper, metal adhesives, ceramics, linoleum, and mirrors (Sullivan 1969),[274] and its compounds are used in pesticides, wood preservatives, paints, and electrical semiconductors. Because of its poisonous action on microorganisms and lower forms of destructive aquatic organisms, it has been used in wood preservatives, paints, insecticides, and herbicides. Sodium arsentite has been used for weed control in lakes and in electrical semiconductors.

In small concentrations, arsenic is found naturally in some bodies of water. In its different forms, including its valence states, arsenic varies in toxicity. Trivalent arsenic is considerably more toxic than the pentavalent species in the inorganic form. It is acutely toxic to invertebrates and for this reason has found application in the control of *Teredo* and other woodborers in the AS^{+3} form. Arsenious trioxide (As_2O_3) has been used for control of the shipworm *Bankia setacia*. In the arsenate form (As^{+5}), it is of relatively low toxicity, *Daphnia* being just immobilized at 18 to 31 mg/l sodium arsenate, or 4.3 to 7.5 mg/l as arsenic, in Lake Erie water (Anderson 1944,[110] 1946[111]). The lethal threshold of sodium arsenate for minnows has been reported as 234 mg/l as arsenic at 16 to 20 C (Wilber 1969).[299]

Arsenic is normally present in sea water at concentrations of 2 to 3 μg/l and tends to be accumulated by oysters and other molluscan shellfish (Sautet et al. 1964,[268] Lowman et al. 1971[221]). Wilber (1969)[299] reported concentrations of 100 mg/kg in shellfish. Arsenic is a cumulative poison and has long-term chronic effects on both aquatic organisms and on mammalian species. A succession of small doses may add up to a final lethal dose (Buchanan 1962).[135] The acute effects of arsenic and its compounds on aquatic organisms have been investigated, but little has been done on the sublethal chronic effects.

Surber and Meehan (1931)[275] found that fish-food organisms generally can withstand concentrations of approximately 1.73 mg/l of arsenious trioxide in sodium arsenite solution. Meinck et al. (1956)[227] reported that arsenic concentrations were toxic at 1.1 to 2.2 mg/l to pike perch (*Stizostedion vitreum*) in 2 days, 2.2 mg/l to bleak in 3 days, 3.1 mg/l to carp (*Cyrinus carpio*) in 4 to 6 days and to eels in 3 days, and 4.3 mg/l to crabs in 11 days.

Recommendation

Because of the tendency of arsenic to be concentrated by aquatic organisms, it is recommended that an application factor of 0.01 be applied to marine 96-hour LC50 data for the appropriate organisms most sensitive to arsenic. On the basis of freshwater and marine toxicity data available, it is suggested that concentrations of arsenic equal to or exceeding 0.05 mg/l constitute a hazard in the marine environment, and levels less than 0.01 mg/l present minimal risk of deleterious effects.

Barium

Barium comes largely from ores ($BaSO_4$, $BaCO_3$). It is being used increasingly in industry. The U.S. consumption in 1968 was 1.6 million tons, a growth of 78 per cent in 20 years (U.S. Department of the Interior, Bureau of Mines 1969).[289] Barium is used in a variety of industrial applications, including paper manufacturing, fabric printing and dyeing, and synthetic rubber production.

All water- or acid-soluble barium compounds are poisonous. However, in sea water the sulfate and carbonate present tend to precipitate barium. The concentration of barium in sea water is generally accepted at about 20 μg/l (Goldberg et al. 1971),[172] although it has been reported as low as 6.2 μg/l (Bowen 1956).[128] Wolgemuth and Broecker (1970)[303] reported a range of 8 to 14 μg/l in the Atlantic and 8 to 31 μg/l in the Pacific, with the lower values in surface waters. Barium ions are thought to be rapidly precipitated or removed from solution by adsorption and sedimentation.

Bijan and Deschiens (1956)[123] reported that 10 to 15 mg/l of barium chloride were lethal to an aquatic plant and two species of snails. Bioassays with barium chloride showed that a 72-hour exposure to 50 mg/l harmed the nervous system of coho salmon (*Oncorhynchus kisutch*) and 158 mg/l killed 90 per cent of the test species (ORSANCO 1960).[245] Barium can be concentrated in goldfish (*Carassius auratus*) by a factor of 150 (Templeton 1958).[279] Soviet marine radioactivity studies showed accumulation of radioactive barium in organs, bones, scales, and gills of fish from the Northeast Pacific (Moiseev and Kardashev 1964[230]). Lowman et al. (1971)[221] listed a concentration factor for barium of 17,000 in phytoplankton, 900 in zooplankton, and 8 in fish muscle.

In view of the widespread use of barium, the effects of low doses of this element and its compounds on marine organisms under different environmental conditions should be determined. Disposal of barium-containing wastes into waters when precipitates could affect rooted aquatics and benthic invertebrates should be avoided.

Recommendation

Because of the apparent concentration of barium by aquatic organisms and the resultant human health hazard, it is recommended that an application factor of 0.05 be applied to marine 96-hour LC50 data for the appropriate organisms most sensitive to barium. On the basis of data available at this time, it is suggested that concentrations of barium equal to or exceeding 1.0 mg/l constitute a hazard in the marine environment, and levels less than 0.5 mg/l present minimal risk of deleterious effects.

Cadmium

U.S. consumption of cadmium was 6,662 short tons in 1968 (U.S. Department of the Interior, Bureau of Mines 1969).[289] These quantities indicate that cadmium might be a significant pollutant.

Pure cadmium is not found in commercial quantities in nature. It is obtained as a by-product of smelting zinc. Cadmium salts in high concentrations have been found in a Missouri spring originating from a mine (up to 1,000 mg/ml cadmium) (ORSANCO 1955),[241] and up to 50 to 170 mg/kg of cadmium are found in superphosphate fertilizers (Athanassiadis 1969).[116] Cadmium is also present in some pesticides. It is being used in increasing amounts by industry (Council on Environmental Quality 1971).[141] Water-carrying pipes are also a source of cadmium (Schroeder 1970)[259] as is food (Nilsson 1969).[239] Cadmium is present in most drainage waters (Kroner and Kopp 1965)[209] and may be contributing substantially to the cadmium present in inshore coastal waters. It is not known, however, whether man's input has resulted in higher levels of cadmium in estuarine or coastal waters. In sea water, cadmium is generally present at about 0.1 µg/l (Goldberg et al. 1971).[172]

Cadmium pollution resulting in the "Itai-itai" disease in the human population has been documented (Yamagata and Shigematsu 1970).[307] Schroeder et al. (1967)[260] have found that oysters may concentrate cadmium from very low levels in ambient water. Cadmium concentrations in some marine plants and animals have been given by Mullin and Riley (1956).[233]

Concern exists that cadmium may enter the diet, like mercury, through seafood. Cadmium, like mercury, could conceivably form organic compounds which might be highly toxic or lead to mutagenic or teratogenic effects.

Cadmium has marked acute and chronic effects on aquatic organisms. It also acts synergistically with other metals. A 15-week LC50 of 0.1 mg/l and inhibition of shell growth for *Crassostrea virginica* (Pringle et al. 1968),[250] and a 96-hour LC50 of 0.03 mg/l cadmium in combination with 0.15 mg/l zinc for fry of chinook salmon (*Oncorhynchus tshawytscha*) (Hublou et al. 1954)[184] have been reported.

Fundulus heteroclitus exposed to 50 mg/l cadmium showed pathological changes in the intestinal tract after 1-hour exposure, in the kidney after 12 hours, and in the gill filaments and respiratory lamellae after 20 hours (Gardner and Yevich 1970).[170] Copper and zinc, when present at 1 mg/l or more, substantially increase the toxicity of cadmium (LaRoche 1972).[211]

Cadmium is concentrated by marine organisms, particularly the molluscs (e.g., *Pecten novazellandicae*), which accumulated cadmium in the calcareous tissues and in the viscera (Brooks and Rumbsby 1965).[133] Lowman et al. (1971)[221] reported a concentration factor of 1000 for cadmium in fish muscle.

Cadmium levels in tissues of Ashy Petrel (*Oceanodroama homochroa*) from coastal waters of California were approximately twice as high as in tissues of Wilson's Petrel (*Oceanites oceanicus*) obtained in Antarctica, which had summered in the North Atlantic and Australian regions, respectively. Cadmium levels in tissues of the Snow Petrel (*Pelagodroma nivea*), a species which does not leave the Antarctic ice pack region, obtained at Hallett Station, Antarctica, were of the same order of magnitude as those in the Wilson's Petrel. Cadmium levels in eggs of the Common Tern (*Sterna hirundo*) from Long Island Sound were in the order of 0.2 mg/kg dry weight, not appreciably higher than those in the Antarctic Tern (*Sterna vittata*) from the Antarctic with levels in the order of 0.1 mg/kg (Anderlini et al. *in press*).[109] Cadmium pollution may therefore be significant locally in estuaries, but on the basis of these limited data, it does not appear to be a problem in more remote marine ecosystems. However, in view of the comparatively unknown effects of cadmium on the marine ecosystem, its apparent concentration by marine organisms, and the human health risk involved in consumption of cadmium-contaminated seafood, it is suggested that there be no artificial additions of cadmium to the marine environment.

Recommendation

The panel recommends that an application factor of 0.01 be applied to marine 96-hour LC50 data for appropriate organisms most sensitive to cadmium. On the basis of data available at this time, it is suggested that concentrations of cadmium equal to or exceeding 0.01 mg/l constitute a hazard in the marine environment as well as to human populations, and levels less than 0.2 μg/l present minimal risk of deleterious effects. In the presence of copper and/or zinc at 1 mg/l or more, there is evidence that the application factor for cadmium should be lower by at least one order of magnitude.

In the absence of sufficient data on the effects of cadmium upon wildlife, it is recommended that cadmium criteria for aquatic life apply also to wildlife.

Cyanides

Most of the available information on toxicity of cyanides is for freshwater organisms, and is discussed in the Freshwater Aquatic Life and Wildlife section, p. 189.

The cyanide radical is a constituent of many compounds or complex ions that may be present in industrial wastes. Cyanide-bearing wastes may derive from gas works, coke ovens, scrubbing of gases in steel plants, metal plating operations, and chemical industries. The toxicity of cyanides varies widely with pH, temperature, and dissolved oxygen concentration. The pH is especially important, since the toxicity of some cyanide complexes changes manyfold over the range commonly found in receiving waters.

"Free cyanide" (CN^- ion and HCN) occurs mostly as molecular hydrogen cyanide, the more toxic form, at pH levels of natural waters as well as in unusually acid waters. Fifty per cent ionization of the acid occurs at pH near 9.3. Free cyanide concentrations from 0.05 to 0.01 mg/l as CN have proved fatal to many sensitive fishes (Jones 1964),[527] and levels much above 0.2 mg/l are rapidly fatal for most species of fish. A level as low as 0.01 mg/l is known to have a pronounced, rapid, and lasting effect on the swimming ability of salmonid fishes.

Chemical determination of the concentration of undissociated, molecular HCN alone may be the best way to evaluate the danger of free cyanide to fish in waters receiving cyanide bearing wastes. Such tests may reveal the occurrence of harmful concentrations of HCN not predictable through bioassay of the wastes. Because an acceptable concentration of HCN or fraction of a LC50 of cyanides and cyanide-bearing effluents has not yet been positively determined, a conservative estimate must be made; and because levels as low as 0.01 mg/l have proved harmful under some conditions, a factor of 0.05 should be applied to LC50 levels.

Recommendation

As a guideline in the absence of data for marine organisms the panel recommends that an application factor of 0.1 be applied to marine 96-hour LC50 data for the appropriate organisms most sensitive to cyanide. On the basis of data available at this time it is suggested that concentrations of cyanide equal to or exceeding 0.01 mg/l constitute a hazard in the marine environment, and levels less than 0.005 mg/l present minimal risk of deleterious effects.

Chromium

Chromium concentrations in seawater average about 0.04 µg/l (Food and Agriculture Organization 1971),[164] and concentration factors of 1,600 in benthic algae, 2,300 in phytoplankton, 1,900 in zooplankton, 440 in soft parts of molluscs, 100 in crustacean muscle, and 70 in fish muscle have been reported (Lowman et al. 1971).[221]

The toxicity of chromium to aquatic life will vary with valence state, form, pH, synergistic or antagonistic effects from other constituents, and the species of organism involved.

In long-term studies on the effects of heavy metals on oysters, Haydu (*unpublished data*)[314] showed that mortalities occur at concentrations of 10 to 12 µg/l chromium, with highest mortality during May, June, and July. Raymont and Shields (1964)[253] reported threshold toxicity levels of 5 mg/l chromium for small prawns (*Leander squilla*), 20 mg/l chromium in the form Na_2CrO_4 for the shore crab (*Carcinas maenus*), and 1 mg/l for the polychaete *Nereis virens*. Pringle et al. (1968)[250] showed that chromium concentrations of 0.1 and 0.2 mg/l, in the form of $K_2Cr_2O_7$, produced the same mortality with molluscs as the controls. Doudoroff and Katz (1953)[150] investigated the effect of $K_2Cr_2O_7$ on mummichogs (*Fundulus heteroclitus*) and found that they tolerated a concentration of 200 mg/l in sea water for over a week.

Holland et al. (1960)[182] reported that 31.8 mg/l of chromium as potassium chromate in sea water gave 100 per cent mortality to coho salmon (*Oncorhynchus kisutch*). Gooding (1954)[173] found that 17.8 mg/l of hexavalent chromium was toxic to the same species in sea water.

Clendenning and North (1960)[141] showed that hexavalent chromium at 5.0 mg/l chromium reduced photosynthesis in the giant kelp (*Macrocystis pyrifera*) by 50 per cent during 4 days exposure.

Most of the available information on toxicity of chromium is for freshwater organisms, and it is discussed in Section III, p. 180.

The chronic toxicity of hexavalent chromium to fish has been studied by Olson (1958),[422] and Olson and Foster (1956,[423] 1957).[424] Their data demonstrated a pronounced cumulative toxicity of chromium to rainbow trout and chinook salmon (*Oncorhynchus tshawytscha*). Duodoroff and Katz (1953)[406] found that bluegills (*Lepomis macrochirus*) tolerated a 45 mg/l level for 20 days in hard water. Cairns (1956),[403] using chromic oxide (CrO_3), found that a concentration of 104 mg/l was toxic to bluegills in 6 to 84 hours. Bioassays conducted with four species of fish gave 96-hour LC50's of hexavalent chromium that ranged from 17 to 118 mg/l, indicating little effect of hardness on toxicity (Pickering and Henderson 1966).[426]

Recently some tests of chronic effects on reproduction of fish have been carried out. The 96-hour LC50 and safe concentrations for hexavalent chromium were 33 and 1.0 mg/l for fathead minnows (*Pimephales promelas*) in hard water (Pickering *unpublished data* 1971),[446] 50 and 0.6 mg/l for brook trout (*Salvelinus fontinalis*) in soft water, and 69 and 0.3 mg/l for rainbow trout (*Salmo gairdneri*) in soft water (Benoit *unpublished data* 1971).[438] Equivalent values for trivalent chromium were little different: 27 mg/l for the 96-hour LC50, and 1.0 mg/l for a safe concentration for fathead minnows in hard water (Pickering *unpublished* data 1971).[446]

For *Daphnia* the LC50 of hexavalent chromium was reported as 0.05 mg/l, and the chronic no-effect level of trivalent chromium on reproduction was 0.33 mg/l (Biesinger and Christensen *unpublished data* 1971).[440] Some data are available concerning the toxicity of chromium to algae. The concentrations of chromium that inhibited growth for the test organisms are as follows (Hervey 1949):[410] Chlorococcales, 3.2 to 6.4 mg/l; Euglenoids, 0.32 to 1.6 mg/l; and diatoms, 0.032 to 0.32 mg/l. Patrick (*unpublished data* 1971)[447] found that 50 per cent growth reduction for two diatoms in hard and soft water occurred at 0.2 to 0.4 mg/l chromium.

Thus it is apparent that there is a great range of sensitivity to chromium among different species of organisms and in different waters. Those lethal levels reported above are 17 to 118 mg/l for fish, 0.05 mg/l for invertebrates, and 0.032 to 6.4 mg/l for algae, the highest value being 3,700 times the lowest one. The apparent "safe" concentration for fish is moderately high, but the recommended maximum concentration of 0.05 mg/l has been selected in order to protect other organisms, in particular *Daphnia* and certain diatoms which are affected at slightly below this concentration.

Recommendation

Because of the sensitivity of lower forms of aquatic life to chromium and its accumulation at all trophic levels, it is recommended that an application factor of 0.01 be applied to marine 96-hour LC50 data for the appropriate organisms most sensitive to chromium. On the basis of data available at this time, it is suggested that concentrations of chromium equal to or exceeding 0.1 mg/l constitute a hazard to the marine environment, and levels less than 0.05 mg/l present minimal risk of deleterious effects. In oyster areas, concentrations should be maintained at less than 0.01 mg/l.

Copper

Copper has been used as a pesticide for eliminating algae in water, and its salts have bactericidal properties. Copper is toxic to invertebrates and is used extensively in marine antifouling paints which release it to the water. It is also toxic to juvenile stages of salmon and other sensitive species (Sprague 1964,[267], 1965,[268] Sigler et al. 1966,[263] Cope 1966[142]).

Copper was the fifth metal in U.S. consumption during 1968, following iron, manganese, zinc, and barium (U.S. Department of the Interior Bureau of Mines 1969).[289] Copper is used for such products as high transmission wires, containers, utensils, and currency because of its noncorroding properties.

Copper is widely distributed in nature and is present in sea water in concentrations ranging from 1 to 25 µg/l. In small amounts, copper is nonlethal to aquatic organisms; in fact, it is essential to some of the respiratory pigments in animals (Wilber 1969).[299] Copper chelated by lignin or citrate has been reported to be as effective as copper ion in controlling algae, but apparently it is not as toxic to fish (Ingols 1955).[186] Copper affected the polychaete *Nereis virens* at levels of approximately 0.1 mg/l (Raymont and Shields 1964)[253] and the shore crab (*Carcinus maenus*) at 1 to 2 mg/l (Wilber 1969).[299] Copper at concentrations of 0.06 mg/l inhibited photosynthesis of the giant kelp (*Macrocystis pyrifera*) by 30 per cent in 2 days and 70 per cent in 4 days (Clendenning and North 1960).[141]

Copper is toxic to some oysters at concentrations above 0.1 mg/l (Galtsoff 1932)[168] and lethal to oysters at 3 mg/l (Wilber 1969).[299] The American oyster (*Crassostrea virginica*) is apparently more sensitive to copper than the Japanese species (*Crassostrea gigas*) (Reish 1964).[254] The 96-hour LC50 for Japanese oysters exposed to copper has been reported as 1.9 mg/l (Fujiya 1960).[165] However, oysters exposed to concentrations as low as 0.13 mg/l turn green in about 21 days (Galtsoff 1932).[168] Although such concentrations of copper are neither lethal to the oysters nor, apparently, harmful to man, green oysters are unmarketable because of appearance. Therefore, in the vicinity of oyster grounds, the recommendation for maximum permissible concentrations of copper in the water is based on marketability, and it is recommended that copper not be introduced into areas where shellfish may be contaminated or where seaweed is harvested.

Copper acts synergistically when present with zinc (Wilber 1969),[299] zinc and cadmium (LaRoche 1972),[211] mercury (Corner and Sparrow 1956),[143] and with pentachlorophenate (Cervenka 1959).[137] Studies on sublethal effects of copper show that Atlantic salmon (*Salmo salar*) will avoid concentrations of 0.0024 mg/l in laboratory experiments (Sprague et al. 1965,[270] Saunders and Sprague 1967,[257] Sprague 1971[269]).

Copper is accumulated by marine organisms, with concentration factors of 30,000 in phytoplankton, 5,000 in the soft tissues of molluscs, and 1000 in fish muscle (Lowman et al. 1971).[221]

Bryan and Hummerstone (1971)[134] reported that the polychaete *Nereis diversicolor* shows a high takeup of copper from copper-rich sediments and develops a tolerance. Mobile predators feeding on this species could receive doses toxic to themselves or accumulate concentrations that would be toxic to higher trophic levels.

Recommendation

It is recommended that an application factor of 0.01 be applied to marine 96-hour LC50 data for the appropriate organisms most sensitive to copper. On the basis of data available at this time, it is suggested that concentrations of copper equal to or exceeding 0.05 mg/l constitute a hazard in the marine environment, and levels less than 0.01 mg/l present minimal risk of deleterious effects.

Iron

Because of the widespread use of iron by man for his many industrial activities, iron is a common contaminant in the aquatic environment. Iron may enter water naturally from iron ore deposits; but iron is more often introduced from acid mine drainage, mineral processing, steel pickling, and corrosion. Iron usually occurs in the ferrous form, when it is released from processing plants or in mine drainage, but becomes rapidly oxidized to the ferric form in natural surface waters. The ferric salts form gelatinous hydroxides, agglomerate and flocculate, settling out on the bottom or becoming adsorbed on various surfaces. Depending on the pH and Eh, groundwater may contain a considerable amount of iron in solution, but well aerated waters seldom contain high, dissolved iron. In the marine environment, iron is frequently present in organic complexes and in adsorbed form on particulate matter.

Most of the investigations on biological effects of iron have been done in fresh water (Knight 1901,[204] Bandt 1948,[117] Minkina 1946,[229] Southgate 1948,[265] Lewis 1960,[215] ORSANCO 1960[245]). Deposition of iron hydroxides on spawning grounds may smother fish eggs, and the hydroxides may irritate the gills and block the respiratory channels of fishes (Southgate 1948,[265] Lewis 1960[215]). Direct toxicity of iron depends on its valence state and whether it is in solution or suspension.

Warnick and Bell (1969)[297] examined the effects of iron on mayflies, stoneflies, and caddisflies and obtained a 96-hour LC50 of 0.32 mg/l for the three insects. Dowden and Bennett (1965)[153] examined the effect of ferric chloride to *Daphnia magna* in static acute bioassays. They noted LC50's of 36, 21, and 15 mg/l for 1, 2, and 4 days, respectively.

Ferric hydroxide flocs removed the diatoms in the process of flocculation and settling, coating the bottom; and the iron precipitate coated the gills of white perch (*Morone americana*), minnows, and silversides in upper Chesapeake Bay (Olson et al. 1941).[242]

Tests on three types of fish gave a lethality threshold for iron at 0.2 mg/l (Minkina 1946)[229] and on carp at 0.9 mg/l if the pH was 5.5 or lower. Ebeling (1928)[155] found that 10 mg/l of iron caused serious injury or death to rainbow trout (*Salmo gairdneri*) in 5 minutes. La Roze (1955)[212] reported that dogfish were killed in 3 hours at 5 mg/l iron, whereas other research (National Council for Stream Improvement 1953)[236] indicated no deaths during one week at 1 to 2 mg/l.

Because of the slightly alkaline condition of sea water, much of the iron introduced to the sea precipitates. This adds a further problem of iron hydroxide flocs contaminating bottom sediments where rooted aquatics and invertebrates could be affected.

Special consideration should be given to avoiding discharge of iron-containing effluents into waters where commercially important bottom species or important food organisms dwell (e.g., oysters, clams, scallops, lobsters, crabs, shrimp, halibut, flounder, and demersal fish eggs and larvae).

Recommendation

On the basis of data available at this time, it is suggested that concentrations of iron equal to or exceeding 0.3 mg/l constitute a hazard to the marine environment, and levels less than 0.05 mg/l present minimal risk of deleterious effects.

Lead

The present rate of input of lead into the oceans is approximately ten times the rate of introduction by natural weathering, and concentrations of lead in surface sea water are greater than in deeper waters (Chow and Patterson 1966).[139] The isotope composition of the lead in surface waters and in recent precipitation is more similar to that of mined ore than to that in marine sediments (Chow 1968).[138] There are almost no data, however, that would suggest that the higher concentrations of lead in surface sea water derived from lead transported through the atmosphere have resulted in higher lead concentrations in marine wildlife. Lead concentrations in Greenland snow have been shown to be 16 times higher in 1964 than in 1904 (Murozumi et al. 1969).[235] In 1968 an estimated 1.8×10^5 tons of lead were introduced to the atmosphere as a result of the combustion of leaded gasoline (Council on Environmental Quality 1971).[144] This represents 14 per cent of the total lead consumption of the United States for that year. Lead poisoning of zoo animals in New York City was attributed to their breathing lead-contaminated air (Bazell 1971).[119]

Blood serum aldolase activity in higher animals exposed to small amounts of lead increased, although there were no overt signs or symptoms of poisoning (Yaverbaum 1963,[308] Wilber 1969[299]). Chronic lead poisoning in man is symptomatically similar to multiple sclerosis (Falkowska et al. 1964).[159] Muscular dystrophy has been reported as occurring in fishes and amphibians (Stolk 1962,[272] Wilber 1969[299]) and in view of these findings could, in fact, be unnatural.

Data are needed on the sublethal, long-term effects of lead on aquatic organisms, particularly those in sea water. Evidence of deleterious effect to freshwater fish has been reported for concentrations of lead as low as 0.1 mg/l (Jones 1938).[197]

Wilder (1952)[300] reported lobster dying in 6 to 20 days when held in lead-lined tanks. Pringle (*unpublished data*)[315] observed a 12-week LC50 of 0.5 mg/l lead and an 18-week LC50 of 0.3 mg/l lead with the oyster (*Crassostrea virginica*). There was noticeable change in gonadal and mantle tissue following 12 weeks exposure at concentrations of 0.1 to 0.2 mg/l of lead. Calabrese et al. (*unpublished data*)[310] found a 48-hour LC25 of 1.73 mg/l and an LC50 of 2.45 mg/l for oyster eggs of the same species.

North and Clendenning (1958)[241] reported that lead nitrate at 4.1 mg/l of lead showed no deleterious effect on the photosynthesis rate in kelp (*Macrocystis pyrifera*) exposed for four days. They concluded that lead is less toxic to kelp than mercury, copper, hexavalent chromium, zinc, and nickel.

Recommendation

In the absence of more definitive information on the long-term chronic effect of lead on marine organisms, it is recommended that concentrations of lead in sea water should not exceed 0.02 of the 96-hr LC50 for the most sensitive species, and that the 24-hour average concentration should not exceed 0.01 of the 96-hour LC50. On the basis of data available at this time it is suggested that concentrations of lead equal to or exceeding 0.05 mg/l constitute a hazard in the marine environment, and levels less than 0.01 mg/l present minimal risk of deleterious effects. Special effort should be made to reduce lead levels even further in oyster-growing areas.

Manganese

Manganese is one of the most commonly used metals in industry. It occurs widely in ores on land and in nodules in the deep sea. U.S. consumption in 1958 exceeded 2.2 million tons, a 45 per cent increase in 20 years (U.S. Department of Interior, Bureau of Mines 1969).[289] The metal is alloyed with iron to produce steel and in smaller quantities with copper for manganese bronze. Its salts are used in inks and dyes, in glass and ceramics, in matches and fireworks, for dry-cell batteries, and in the manufacture of paints and varnishes.

Manganese is often found with iron in ground waters, and it can be leached from soil and occur in drainage in high concentrations. The carbonates, oxides, and hydroxides are slightly soluble, so that manganous and manganic ions are rarely present in surface water in excess of 1 mg/l. Manganese is present in sea water at about 2 μg/l in the Mn^{+2} form, and is concentrated through biochemical processes to form manganese nodules, found mainly in the deep sea.

Manganese may have different effects on the lower trophic levels in fresh water and sea water. Concentrations of manganese above 0.005 mg/l had a toxic effect on certain algae in reservoirs (Guseva 1937,[174] 1939[175]), while 0.0005 mg/l in sea water stimulated growth and multiplication of certain phytoplankton (Harvey 1947).[178] Anderson (1944)[110] reported the threshold of immobilization of *Daphnia magna* as 0.63 mg/l of $KMnO_4$ and the threshold concentration for immobilization of *Daphnia magna* in Lake Erie water as 50 mg/l of $MnCl_2$ (Anderson 1948).[112] Bringmann and Kuhn (1959a)[131] reported the threshold effect for the same species as 50 mg/l of $MnCl_3$ as manganese in River Havel water at 23 C.

For the flatworm *Polycelis nigra*, the threshold concentration of manganese was reported as 700 mg/l as manganese chloride and 660 mg/l as manganese nitrate (Jones 1940).[199] Tests on organisms on which fish feed, i.e., crustacea, worms, and insect larvae, showed no apparent harm at 15 mg/l of manganese during a 7-day exposure (Schweiger 1957).[261] River crayfish were found to tolerate 1 mg/l (Meinck et al. 1956).[227]

The toxicity of manganese to fish depends on a number of factors which may vary from one situation to another. There is an apparent antagonistic action of manganese toward nickel toxicity for fish (Blabaum and Nichols 1956).[125] This may be true also for cobalt and manganese in combination, as noted for terrestrial plant life (Ahmed and Twyman 1953).[108]

Stickleback survived 50 mg/l manganese as manganese sulphate for 3 days, whereas eels withstood 2700 mg/l for 50 hours (Doudoroff and Katz 1953).[150] The lethal concentration of manganese for stickleback was given as 40 mg/l by Jones (1939),[198] and he noted that the toxic action was slow. The minimum lethal concentration of manganese nitrate for sticklebacks in tap water has been reported to be 40 mg/l as manganese (Anderson 1948,[112] Murdock 1953).[234]

The average survival times of stickelback in manganous nitrate solution were one week at 50 mg/l, four days at 100 mg/l, two days at 150 mg/l, and one day at 300 mg/l, all measured as manganese (Murdock 1953).[234] Young eels tolerated 1500 mg/l manganous sulphate for more than 25 hours (Doudoroff and Katz 1953).[150] Oshima (1931)[246] and Iwao (1936)[189] reported the lethal thresholds of manganous chloride and manganous sulphate for fish in Japan to be about 2400 and 1240 mg/l of manganese, respectively. They found that permanganates (Mn^{+7}) killed fish at 2.2 to 4.1 mg/l manganese in 8 to 18 hours, but this high oxidation form is quite unstable in water. Tench, carp, and trout tolerated 15 mg/l of manganese during 7 days exposure (Schweiger 1957).[261]

Manganous chloride was found to be lethal to minnows (*Fundulus*) in fresh water in six days at 12 mg/l $MnCl_2$; for the small freshwater fish Orizias, the 24 hour lethal concentration was about 7850 mg/l (Doudoroff and Katz 1953);[150] and for other fish 5500 mg/l (Oshima 1931,[246] Iwao, 1936[189]). The highest concentration tolerated by eels for 50 hours was 6300 mg/l (Doudoroff and Katz 1953).[150] Meinck et al. (1956)[227] noted the first toxic effects for fish of $MnCl_2$ at 330 mg/l, with the lethal concentration at 800 mg/l.

Only a few studies of sublethal effects of manganese on fish have been reported. Ludemann (1953)[222] noted some of the symptoms of toxicity of manganese to fish, crabs, and fish food organisms. Abou-Donia and Menzel (1967)[103] noted an effect of 1.25×10^{-4} M manganese (6.9 mg/l) on the enzyme acetylcholinesterase in shiner perch.

In studies on the uptake of radionuclides on the Pacific testing grounds of Bikini and Eniwetok, it was found that the neutron-induced isotope of manganese ^{54}Mn was concentrated by as much as 4000 in phytoplankton and 12,000 in the muscle or soft tissue of mollusks (Lowman 1960,[220] Lowman et al. 1971[221]). Goldberg et al. (1971)[172] list the concentration factor of manganese in marine plants and animals as approximately 3000.

Recommendation

In view of the evidence for concentration of manganese by marine organisms, an application factor of 0.02 of the 96 hr LC50 for the most sensitive species to be protected is recommended.

Until more complete information on acute and sublethal effects of manganese on marine organisms is available, it is suggested that concentrations of 0.1 mg/l or more of total manganese in the marine environment may constitute a hazard, and concentrations of less than 0.02 mg/l present minimal risk.

Mercury

Mercury naturally leaches from cinnabar (HgS) deposits. Man-made sources of mercury have been in plastics manufacture, where mercury oxide is used as a catalyst, chloralkali plants where mercury cells are used, mercurial slimacides used in the pulp and paper industry and in other forest product anti-fungal applications, seed dressings used in combatting smuts and other fungal diseases afflicting seeds, and in anti-fouling paints. An estimated 5000 tons of mercury per year are transferred from the continents to the oceans as a result of continental weathering (Klein and Goldberg 1970).[203] Global production of mercury is currently about twice as high, in the order of 9000 metric tons per year (Hammond 1971).[176] The burning of petroleum releases in the order of 1600 tons of mercury into the atmosphere per year (Bertine and Goldberg 1971).[122] A conservative estimate of the amount of mercury released per year into the global environment from the burning of coal is in the order of 3000 tons (Joensuu 1971).[195] The total amount of mercury estimated to be in the oceans is in the order of 10^8 metric tons, approximately three orders of magnitude higher than the total amount of mercury consumed in the United States since 1900. Mercury in marine organisms is, therefore, most probably of natural origin except in localized areas.

One hundred and eleven persons were reported poisoned, 41 died, and others suffered serious neurological damage as a result of eating fish and shellfish which had been contaminated with mercury discharged into Minamata Bay by a plastics manufacturing plant between 1950 and 1960 (Irukayama 1967).[187] In 1965, another poisoning incident was reported in Niigata, Japan, where 5 people died and 26 suffered irreversible neurological damage (Ui 1967).[292] In Minamata it was also found that cats eating the contaminated fish and shellfish took suicidal plunges into the sea, an uncommon occurrence with these mammals (Ui and Kitamura 1970).[293]

Metallic mercury can be converted by bacteria into methyl mercury (Jensen and Jernelöv 1969,[192] Jernelöv 1969,[194] Löfroth 1969[218]). Organometallic mercury is much more toxic than the metallic mercury and enters the food cycle through uptake by aquatic plants, lower forms of animal life, and fish (Jernelöv 1969).[194] The concentration factor of mercury in fish was reported as 3,000 and higher (Hannerz 1968,[177] Johnels and Westermark 1969[196]). A voluntary form of control was imposed in Sweden where anglers were requested not to eat more than one fish per week from a given lake to minimize human intake.

High mercury concentrations in birds and fish were reported on the Canadian prairies in 1969 (Fimreite 1970,[160] Wobeser et al. 1970,[301] Bligh 1971[126]). The source of the mercury in the birds was apparently mercurial seed dressing consumed with grain by the birds; whereas in fish, mercury came largely from emissions of a chlor-alkali plant using a mercury cell.

The Food and Drug Directorate of Canada set a level of 0.5 parts per million as the maximum permissible concentration in fish products. The 0.5 parts per million level was set as an interim guideline, not a regulation based on any known safe level for mercury (Canada Food and Drug Directorate, *personal communication*).[311] A similar guideline was adopted in the U.S. (Kolbye 1970).[206] These limits were based on the lethal concentrations found in Minamata Bay, Japan, and on the levels set by the World Health Organization (WHO) in cooperation with the Food and Agricultural Organization (FAO). The level set by WHO/FAO was 0.05 ppm, based on total food (WHO 1967).[305] The concentrations which were found lethal to the Japanese consuming fish and shellfish contaminated by mercury were 10 to 50 mg/kg total mercury (Birke et al. 1968).[124] The Swedish limit was 1.0 ppm of mercury in fish (Berglund and Wretling 1967)[121] based on dry weight, which is equivalent to 0.2 ppm wet weight (Wallace et al. 1971).[295]

Although the emphasis has been on the effects of mercury on man, aquatic organisms can be affected by various mercury compounds. Mercury markedly alters the epithelium of skin and gills in fishes (Schweiger 1957).[261] Mercuric chloride in water containing developing eggs of *Paracentrotus lividis* brought about a severe disturbance of development at 10 μg/l (Soyer 1963).[266] A concentration of 5 μg/l retarded development markedly. These studies suggested that the threshold for harmful effects of mercuric chloride on developing eggs of *Paracentrotus* was around 2 to 3 μg/l (Soyer 1963).[266] Studies conducted on developing salmon eggs (*Oncorhynchus nerka* and *O. gorbuscha*) at the International Pacific Salmon Fisheries Commission Laboratory in Cultus Lake, B.C., showed that concentrations of mercury at levels exceeding 3 μg/l mercury derived from mercuric sulfate led to severe deformities (Servizi, *unpublished data*).[316] Studies are needed to examine the effects of those concentrations which are accumulated by fish over a longer period of time.

Ukeles (1962)[283] reported that 60 μg/l of ethyl mercury phosphate was lethal to all species of marine phytoplankton tested, and that as little as 0.1 to 0.6 μg/l of alkyl mercury introduced into sea water will inhibit photosynthesis and growth. Clendenning and North (1960)[111] reported that mercury added as mercuric chloride caused 50 per cent inactivation of photosynthesis of giant kelp (*Macrocystis pyrifera*) at 50 μg/l during 4 days exposure, a 15 per cent decrease in photosynthesis at 100 μg/l in 1 day, and complete inactivation in 4 days.

Woelke (1961)[302] reported that 27 μg/l of mercury as mercuric chloride was lethal to bivalve larvae. The learning behavior of goldfish (*Carassius auratus*) was affected after two days by 3 μg/l mercuric chloride (Weir and Hine 1970).[298] Trace amounts of copper increase the toxicity of mercury (Corner and Sparrow 1956).[143]

Mercury concentrations in tissues of the Ashy Petrel (*Oceanodroma homochroa*) from the coastal waters of California, the site of most of the mercury mines in the United States, are in the same order of magnitude as mercury concentrations in tissues of the Snow Petrel (*Pelagodroma nivea*), which inhabits the Antarctic pack ice. Mercury concentrations in nine eggs of the Common Tern (*Sterna hirundo*) from Long Island Sound were only slightly higher than in nine eggs of the Antarctic Tern (*Sterna vittata*) from the Antarctic (Anderlini et al. *in press*).[109]

Environmental residues of mercury in Sweden, as measured by concentrations of mercury in feathers of several species of birds, rose dramatically in the years following 1940 and were attributed to alkyl-mercury compounds used as seed dressings (Berg et al. 1966).[120] This use of mercury caused the death of numbers of seed-eating birds (Borg et al. 1969),[130] but it does not necessarily contaminate aquatic ecosystems (Johnels and Westermark 1969).[196] Feathers of two species of fish-eating birds, the Osprey (*Pandion haliaetus*) and the Great-crested Grebe (*Pocideps cristatus*), have shown a gradual increase in mercury concentration since approximately 1900, paralleling the increase in industrial use of mercury in Sweden (Johnels and Westermark 1969).[196] Experimental work in Sweden has shown that when pheasants were fed wheat treated with methyl-mercury dicyandiamide, decreased hatchability of eggs was associated with mercury concentrations in the eggs from 1.3 to 2.0 mg/kg of the wet weight contents (Borg et al. 1969).[130] It has been suggested that environmental mercury may impair the reproductive capacity of bird species at the tops of food chains, such as falcons (Fimreite et al. 1970),[161] and in Finland mercury may have contributed to the decline of the Whitetailed Sea Eagle (*Haliaetus albicilla*) in regions where the species feeds upon marine fish and marine birds (Henriksson et al. 1966).[180] Conclusive evidence that mercury has impaired the reproductive capacity of any species of wildlife, however, has not yet been obtained and further research is necessary. Fish-eating birds and mammals are the species most likely to be affected because of their position at the top of the food chain.

The high natural levels of mercury in the marine environment and the significant additions due to natural weathering, as well as the documented hazard to marine aquatic life and to humans through marine foods, make it desirable to eliminate inputs of mercury to the marine environment beyond those occurring through continental weathering.

Recommendation

On the basis of data available at this time, it is suggested that concentrations of mercury equal to or exceeding 0.10 μg/l constitute a hazard in the marine environment.

In the absence of sufficient data on the effects of mercury in water upon wildlife, the recommendations established to protect aquatic life and public water supplies should also apply to protect wildlife.

Nickel

Nickel does not occur naturally in elemental form. It is present as a constituent in many ores, minerals and soils, particularly in serpentine-rock-derived soils.

Nickel is comparatively inert and is used in corrosion-resistant materials, long-lived batteries, electrical contacts, spark plugs, and electrodes. Nickel is used as a catalyst in hydrogenation of oils and other organic substances. Its salts are used for dyes in ceramic, fabric, and ink manufacturing. Nickel may enter waters from mine wastes, electroplating plants, and from atmospheric emissions.

Nickel ions are toxic, particularly to plant life, and may exhibit synergism when present with other metallic ions. Nickel salts in combination with a cyanide salt form moderately toxic cyanide complexes which, as nickel sulfate combined with sodium cyanide, gave a 48-hour LC50 of 2.5 mg/l and a 96-hour LC50 of 0.95 mg/l as CN^-, using fathead minnows (*Pimephales promelas*) at 20 C (Doudoroff 1956).[148] Alkaline conditions reduced toxicity of a nickel cyanide complex considerably, with concentrations below 100 mg/l showing no apparent toxic effect on fish.

Nickel salts can substantially inhibit the biochemical oxidation of sewage (Malaney et al. 1959).[223] In fresh waters, nickel has been reported to be less toxic to fish and river crabs than zinc, copper, and iron (Podubsky and Stedronsky 1948).[248] However, other investigators found nickel to be more toxic to fish than iron and manganese (Doudoroff and Katz 1953).[150]

Ellis (1937)[156] reported that nickelous chloride from electroplating wastes did not kill goldfish (*Carassius auratus*) at 10 mg/l during a 200-hour exposure in very soft water. Wood (1964)[304] reported that 12 mg/l of nickel ion kill fish in 1 day and 0.8 mg/l kill fish in 10 days. Doudoroff and Katz (1953)[150] reported survival of stickleback (*Gasterosteus aculeatus*) for 1 week in 1 mg/l of nickel as $Ni(NO_3)_2$.

The lethal limit of nickel to sticklebacks has been reported as 0.8 mg/l (Murdock 1953)[234] and 1.0 mg/l (Jones 1939).[198] The median lethal concentration of nickel chloride ($NiCl_2,6H_2O$) was reported as 4.8 mg/l for guppies (*Becilia reticulata*) (Shaw and Lowrance 1956).[262] Goldfish (*Carassius auratus*) were killed by nickel chloride at 4.5 mg/l as nickel in 200 hours (Rudolfs et al. 1953).[256] Tarzwell and Henderson (1960)[278] reported 96-hour LC50's for fathead minnows (*Pimephales promelas*) as 4.0 mg/l in soft water and 24 mg/l in hard water, expressed as $NiCl_2,6H_2O$. Anderson (1948)[112] reported a threshold concentration of nickel chloride for immobilization of *Daphnia* in Lake Erie water at 25 C to be less than 0.7 mg/l in 64 hours of exposure. Bringmann and Kuhn (1959a,[131] 1959b[132]) reported nickel chloride threshold concentrations as nickel of 1.5 mg/l for *Scenedesmus*, 0.1 mg/l for *Escherichia coli*, and 0.05 mg/l for *Microregma*.

Nickel is present in sea water at 5 to 7 μg/l, in marine plants at up to 3 mg/l, and in marine animals at about 0.4 mg/l.

Marine toxicity data for nickel are limited. The top minnow *Fundulus* was found to survive in concentrations of 100 mg/l Nickel from the chloride in salt water, although the same species was killed by 8.1 mg/l of the salt (3.7 mg/l Ni) in tap water (Thomas cited by Doudoroff and Katz 1953).[150] Long-term studies on oysters (Haydu *unpublished data*)[314] showed substantial mortality at a nickel concentration of 0.12 mg/l. Calabrese et al. (*unpublished data*)[310] found 1.54 mg/l of nickel to be the LC50 for eggs of the oyster (*Crassostrea virginica*).

Recommendation

It is recommended that an application factor of 0.02 be applied to 96-hour LC50 data on the most sensitive marine species to be protected. Although limited data are available on the marine environment, it is suggested that concentrations of nickel in excess of 0.1 mg/l would pose a hazard to marine organisms, and 0.002 mg/l should pose minimal risk.

Silver

Silver is one of the more commercially important metals; 4,938 tons were consumed in the U.S. during 1968, excluding that used for monetary purposes (U.S. Department of the Interior, Bureau of Mines 1969).[289] It is the best known conductor of heat and electricity. Although not oxidized by air, silver is readily affected by hydrogen sulfide to form the black silver sulfide.

Silver has many uses. In addition to making currency, it is used for photographic purposes, for various chemical purposes, and also in jewelry making and in silverplating of cutlery.

Silver is toxic to aquatic animals. Concentrations of 400 μg/l killed 90 per cent of test barnacles (*Balanus balanoides*) in 48 hours (Clarke 1947).[140] Concentrations of silver nitrate from 10 to 100 μg/l caused abnormal or inhibited development of eggs of *Paracentrotus* and concentrations of 2 μg/l of silver nitrate delayed development and caused deformation of the resulting plutei (Soyer 1963).[266] Adverse effects occurred at concentrations below 0.25 μg/l of silver nitrate, and several days were required to eliminate adverse effects by placing organisms in clean water (Soyer 1963).[266] Silver nitrate effects on development of *Arbacia* have been reported at approximately 0.5 μg/l (Soyer 1963,[266] Wilber 1969[299]). In combination with silver, copper acts additively on the development of *Paracentrotus* eggs (Soyer 1963).[266] On a comparative basis on studies on Echinoderm eggs (Soyer 1963),[266] silver has been found to be about 80 times as toxic as zinc, 20 times as toxic as copper, and 10 times as toxic as mercury.

Calabrese et al. (*unpublished manuscript*)[310] noted an LC50 of 0.006 mg/l silver for eggs of the American oyster (*Crassostrea virginica*). Jones (1948)[200] reported that the lethal concentration limit of silver, applied as silver nitrate, for sticklebacks (*Gasterosteus aculeatus*) at 15 to 18 C was 0.003 mg/l, which was confirmed approximately by Anderson (1948),[112] who found 0.0048 mg/l to be the toxic threshold for sticklebacks. Jackim et al. (1970)[190] reported adverse effects on the liver enzymes of the killifish *Fundulus heteroclitus* at 0.04 mg/l of silver.

The sublethal responses to silver compounds may be great, in view of the effects on developing eggs; and further research should be conducted on effects of sublethal concentrations of silver compounds by themselves and in combination with other chemicals. The disruption of normal embryology or of nutrition could be of much greater importance than direct mortality in the perpetuation of the species.

Concentrations of silver cannot exceed that permitted by the low solubility product of silver chloride. However, silver complexes may be present, and their effects are unknown.

Recommendation

It is recommended that the concentrations of silver in marine waters not exceed 0.05 of the 96-hour LC50 for the appropriate species most sensitive to silver. On the basis of data available at this time, it is suggested that concentrations of silver equal to or exceeding 5 μg/l constitute a hazard to the marine environment, and levels less than 1 μg/l present minimal risk of deleterious effects.

Vanadium

Vanadium occurs in various minerals, such as chileite and vanadinite. It is used in the manufacture of vanadium steel. Vanadates were used at one time to a small extent for medicinal purposes. Vanadium has been concentrated by certain marine organisms during the formation of oil-bearing strata in geological time. Consequently, vanadium enters the atmosphere through the combustion of fossil fuels, particularly oil. In addition, eighteen compounds of vanadium are used widely in commercial processes (Council on Environmental Quality 1971).[141]

Recommendation

It is recommended that the concentration of vanadium in sea water not exceed 0.05 of the 96-hour LC50 for the most sensitive species.

Zinc

Most of the available information on zinc toxicity is for freshwater organisms, and for this reason the reader is referred to the discussion of zinc in Section III, p. 182.

The acute lethal toxicity of zinc is greatly affected by water hardness (see Figure III–7). Pickering and Henderson (1966)[426] determined the 96-hour LC50 of zinc for fathead minnows (*Pimephales promelas*) and bluegills (*Lepomis macrochirus*) using static test conditions. For fathead minnows in soft water (20 mg/l as $CaCO_3$) the LC50 was 0.87 mg/l, and in hard water (360 mg/l as $CaCO_3$) it was 33 mg/l. Bluegills were more resistant in both waters. Similarly the lethal threshold concentration was 3 or 4 times as high for coarse fish as for trout (*Salvelinus fontinalis*) (Ball 1967).[398]

The 24-hour LC50 of zinc for rainbow trout (*Salmo gairdneri*) was reduced only 20 per cent when the fish were forced to swim at 85 per cent of their maximum sustained swimming speed (Herbert and Shurben 1964).[409] The maximum effect of a reduction in dissolved oxygen from 6 to 7 mg/l to 2 mg/l on the acute toxicity of zinc was a 50 per cent increase (Lloyd 1961,[413] Cairns and Scheier 1958,[404] Pickering 1968).[425] The effects are small in comparison to the difference between acutely toxic and safe concentrations. The recommended application factor recognizes these effects.

A chronic test in hard water (200 mg/l as $CaCO_3$), involving fathead minnow reproduction, determined the safe concentration of zinc to be between 0.03 mg/l, which had no effect, and 0.18 mg/l, which caused 83 per cent reduction in fecundity (Brungs 1969).[402] Using the 96-hour LC50 of 9.2 mg/l, the ratio of the above no-effect concentration to the LC50 is 0.0034. Interpolation suggests that about 0.005 of the LC50 would cause 20 per cent reduction of fecundity, making the best estimate of a valid application factor close to 0.005.

There was a reduction in reproduction of *Daphnia magna* at a zinc concentration of 0.10 mg/l using soft water (45 mg/l as $CaCO_3$) (Biesinger and Christensen *unpublished data* 1971).[440] No effect was observed at 0.07 mg/l, which indicated that *Daphnia magna* was more resistant to zinc than the fathead minnow.

Avoidance reactions by rainbow trout in the laboratory have been caused by 0.01 of the LC50 of zinc (Sprague 1968a).[431]

Recommendation

Because of the bioaccumulation of zinc through the food web, with high concentrations occurring particularly in the invertebrates, it is recommended that an application factor of 0.01 be applied to marine 96-hour LC50 data for the appropriate organisms most sensitive to zinc. On the basis of data available at this time, it is suggested that concentrations of zinc equal to or exceeding 0.1 mg/l constitute a hazard in the marine environment, and levels less than 0.02 mg/l present minimal risk of deleterious effects.

It should be noted that there is a synergistic effect when zinc is present with other heavy metals, e.g., Cu and Cd, in which case the application factor may have to be lowered by an order of magnitude (LaRoche 1972).[211]

APPENDIX 27

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Permit No. CA0110531
Application No.

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Federal Water Pollution Control Act, as amended, (33 U.S.C. 1251 et. seq; the "Act"),

The Union Oil Company of California
2427 E. Harbor Boulevard
Ventura, California 93003

is authorized to discharge from a facility located at

Platform A - Parcel 0241
Santa Barbara Channel

to receiving waters named

The Pacific Ocean at coordinates: Lat. 34°19'55"
Long. 119°36'50"

in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, and III hereof.

This permit shall become effective on January 23, 1975.

This permit and the authorization to discharge shall expire at midnight, September 1, 1977.

Signed this 23rd day of December, 1974.

For the Regional Administrator

Frank M Covington

Director, Enforcement Division

PA Form 3320-4 (10-73)

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning the effective date of this permit and lasting through September 1, 1977 the permittee is authorized to discharge from outfall(s) serial number(s) 001 - Produced Brine

a. Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	kg/day (lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow—m^3/Day (MGD)	—	—	—	—	Weekly	Average 4 measureme
Settleable Solids	--	--	0.1 ml/l	0.2 ml/l	Monthly	Discrete
* Temperature	--	--	--	--	Monthly	Discrete
* Arsenic	--	--	--	--	Once/6 Months	Composite
* Cadmium	--	--	--	--	Once/6 Months	Composite
* Total Chromium	--	--	--	--	Once/6 Months	Composite
* Copper	--	--	--	--	Once/6 Months	Composite
* Lead	--	--	--	--	Once/6 Months	Composite
* Mercury	--	--	---	--	Once/6 Months	Composite
* Nickel	--	--	--	--	Once/6 Months	Composite
* Silver	--	--	--	--	Once/6 Months	Composite
* Zinc	--	--	--	--	Once/6 Months	Composite
* Phenolic Compounds	--	--	--	--	Once/6 Months	Composite
* Toxicity Bioassay	--	--	--	--	Once/6 Months	Composite

b. The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly by discrete sample.

c. There shall be no discharge of floating solids or visible foam in other than trace amounts.

d. Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Effluent as discharged to the Pacific Ocean from the Oil/Water treatment system.

*If the results of the above monitoring programs so indicate, the Regional Administrator may, upon due notice, impose such permit conditions, including but not limited to effluent limits, as he determines are necessary to carry out the provisions of the Act, or amendments thereto.

e. The discharge of oil based drilling muds or well cuttings containing oil is prohibited.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

2. Additional requirements during the period beginning Sept. 1, 1975 and lasting through Sept. 1, 197 the permittee is authorized to discharge from outfall(s) serial number(s) 001 - Produced Brine

Such discharges shall be limited and monitored by the permittee as specified below:

a.

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	kg/day (lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow—m³/Day (MGD)	—	—	—	—		
Suspended Solids	--	--	50 mg/l	75 mg/l	Monthly	Composite
Oil and Grease	--	--	25 mg/l	50 mg/l	Monthly	Discrete

b. Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): effluent as discharged to Pacific Ocean from oil/water treatment system.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS /‾ Based upon a design treatment capacity of 4.38×10^{-5} cubic meters per second (1,000 gallons per day)_/

3. During the period beginning the effective day of this permit and lasting through July 1, 1977 the permittee is authorized to discharge from outfall(s) serial number(s) 002 - Sanitary Waste Discharge

(a) Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations kg/day (lbs/day) Average 30 day	7 day	Daily Max	Other Units (Specify) Average 30 day	7 day	Daily Max	Monitoring Requirements Measurement Frequency	Sample Type
Flow—m³/Day (MGD)	--	--	--	--	--	--	Monthly	Estimat
Biochemical Oxygen Demand*	(--)	(--)	(--)	-- mg/l	-- mg/l	--	Monthly	Composi
Suspended Solids*	(--)	(--)	(--)	-- mg/l	-- mg/l	--	Monthly	Compos
Fecal Coliform Bacteria	--	--	--	-- /100 ml	-- /100 ml	-- /100 ml	Monthly	Discret
Settleable Solids	--	--	--	-- ml/l	--	-- ml/l	Monthly	Disc

*Both the influent and the effluent shall be monitored.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly by discrete sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): effluent from sanitary treatment facility.

e. After review of effluent monitoring representing at least one year of discharge from the permittee's facility, the Regional Administrator will, upon due notice, revise this permit to establish interim effluent limits. Such revision of this permit may also include an Implementation Schedule for an abatement program, or other appropriate conditions, to achieve the interim limits.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS /_ Based upon a design treatment capacity of 4.38x10^{-5} cubic meters per second (1,000 gallons per day)_/

4. During the period beginning July 1, 1977 and lasting through September 1, 1977 the permittee is authorized to discharge from outfall(s) serial number(s) 002 Sanitary Waste Discharge

a. Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations kg/day (lbs/day) Average 30 day	Average 7 day	Daily Max	Other Units (Specify) Average 30 day	Average 7 day	Daily Max	Monitoring Requirements Measurement Frequency	Sample Type
Flow—m^3/Day (MGD)	--	--	--	--	--	--	Monthly	Estimat
Biochemical Oxygen* Demand	1.1 (2.5)	1.7 (3.8)	3.3 (7.5)	30 mg/l	45 mg/l	--	Monthly	Composi
Suspended Solids*	1.1 (2.5)	1.7 (3.8)	3.3 (7.5)	30 mg/l	45 mg/l	--	Monthly	Composi
Fecal Coliform Bacteria	--	--	--	200 /100 ml	400/100 ml	2000/100 ml	Monthly	Discret
Settleable Solids	--	--	--	0.1 ml/l	--	0.2 ml/l	Monthly	Discret

*Both the influent and the effluent shall be monitored.

. The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly by discrete sample.

. There shall be no discharge of floating solids or visible foam in other than trace amounts.

d. Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Influent and effluent of sanitary treatment system as specified above.

e. The monthly average removal efficiency for Biochemical Oxygen Demand and Suspended Solids shall not be less than 85%

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS [Based on a maximum daily flow volume of $2.6\text{x}10^{-2}$ cubic meters per second (0.6 mgd)]

5. During the period beginning the effective date of this permit and lasting through September 1, 1977. the permittee is authorized to discharge from outfall(s) serial number(s) 003 - Compressor Cooling Water

a. Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	kg/day (lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow—m³/Day (MGD)	—	—	—	—	Monthly	Average 8 readings per day
Oil and Grease	--	--	10	15	Monthly	Discrete
Temperature	--	--	--	20°F Above Ambient	Monthly*	Discrete

*Both the discharge and the receiving water are to be monitored.

b. The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored Monthly by discrete sample.

c. There shall be no discharge of floating solids or visible foam in other than trace amounts.

d. Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): at a point where all cooling water sources are combined prior to discharge.

B. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

Within sixty (60) days of the effective date of this permit, the permittee shall provide to the Regional Administrator an Implementation Schedule for an abatement program to achieve, by September 1, 1975, the effluent limits established in A2(a). Upon approval of the Regional Administrator the final and interim dates contained in this schedule shall become a condition of this permit.

Within sixty (60) days of the effective date of this permit, the permittee shall provide to the Regional Administrator an Implementation Schedule for an abatement program to achieve, by July 1, 1977, the effluent limits established in A.4.a.e. Upon approval of the Regional Administrator the final and interim dates contained in this schedule shall become a condition of this permit.

2. No later than 14 calendar days following a date identified in the above schedule of compliance, the permittee shall submit either a report of progress or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

C. MONITORING AND REPORTING

1. *Representative Sampling*

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. *Reporting*

Monitoring results obtained during the previous 3 months shall be summarized for each month and reported on a Discharge Monitoring Report Form (EPA No. 3320-1), postmarked no later than the 28th day of the month following the completed reporting period. The first report is due on Sept. 28, 1974 . Duplicate signed copies of these, and all other reports required herein, shall be submitted to the Regional Administrator at the following address:

Regional Administrator
Environmental Protection Agency
Region IX, Attn: ENCMR
100 California Street
San Francisco CA 94111

3. *Definitions*

a. The "daily average" discharge means the total discharge by weight during a calendar month divided by the number of days in the month that the production or commercial facility was operating. Where less than daily sampling is required by this permit, the daily average discharge shall be determined by the summation of all the measured daily discharges by weight divided by the number of days during the calendar month when the measurements were made.

b. The "daily maximum" discharge means the total discharge by weight during any calendar day.

4. *Test Procedures*

Test procedures for the analysis of pollutants shall conform to regulations published pursuant to Section 304(g) of the Act, under which such procedures may be required.

5. *Recording of Results*

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

a. The exact place, date, and time of sampling;

b. The dates the analyses were performed;

c. The person(s) who performed the analyses;

d. The analytical techniques or methods used; and

e. The results of all required analyses.

6. *Additional Monitoring by Permittee*

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report Form (EPA No. 3320-1). Such increased frequency shall also be indicated.

7. *Records Retention*

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, or longer if requested by the Regional Administrator ,

A. MANAGEMENT REQUIREMENTS

1. *Change in Discharge*

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by submission of a new NPDES application or, if such changes will not violate the effluent limitations specified in this permit, by notice to the permit issuing authority of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. *Noncompliance Notification*

If, for any reason, the permittee does not comply with or will be unable to comply with any daily maximum effluent limitation specified in this permit, the permittee shall provide the Regional Administrator with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. *Facilities Operation*

The permittee shall at all times maintain in good working order and operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit.

4. *Adverse Impact*

The permittee shall take all reasonable steps to minimize any adverse impact to navigable waters resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. *Bypassing*

Any diversion from or bypass of facilities necessary to maintain compliance with the terms and conditions of this permit is prohibited, except (i) where unavoidable to prevent loss of life or severe property damage, or (ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permittee shall promptly notify the Regional Administrator writing of each such diversion or bypass.

6. *Removed Substances*

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering navigable waters.

7. *Power Failures*

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

a. In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

b. Halt, reduce or otherwise control production and/or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

B. RESPONSIBILITIES

1. *Right of Entry*

The permittee shall allow the Regional Administrator, and/or his authorized representatives, upon the presentation of credentials:

a. To enter upon the permittee's premises where an effluent source is located or in which any records are required to be kept under the terms and conditions of this permit; and

b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

2. *Transfer of Ownership or Control*

In the event of any change in control or ownership of facilities from which the authorized discharges emanate, the permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Regional Administrator.

3. *Availability of Reports*

Except for data determined to be confidential under Section 308 of the Act, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the office of the Regional Administrator. As required by the Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Act.

4. *Permit Modification*

After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including, but not limited to, the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

5. *Toxic Pollutants*

Notwithstanding Part II, B-4 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

6. *Civil and Criminal Liability*

Except as provided in permit conditions on "Bypassing" (Part II, A-5) and "Power Failures" (Part II, A-7), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. *Oil and Hazardous Substance Liability*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Act.

8. *State Laws*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation under authority preserved by Section 510 of the Act.

9. *Property Rights*

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

10. *Severability*

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

PART III

OTHER REQUIREMENTS

A. Effluent Limitations and Monitoring Requirements.

The discharge shall not cause objectionable odors at the surface of the receiving waters.

B. Monitoring and Reporting.

1. The monitoring requirements establish in condition A1(a) are contingent upon the occurance of a discharge. If no discharge occurs during the monitoring period, the permittee shall so state on the monitoring report form.

2. If the permittee is unable, for any reason, to comply with any of the effluent limits of this permit, the permittee shall promptly initiate a monitoring program to analyse the discharge at least once every day for those constituents for which the effluent limits have been violated. Such daily analyses shall continue until compliance with the effluent limits has been attained, or until such time as the Regional Administrator determines to be appropriate. The results of such monitoring programs shall be included in the Discharge Monitoring Reports required by condition B.2.

3. Additional Definitions.

a. Maximum Concentration

Maximum concentration limits shall be applied to the concentration values (milligrams per liter, mg/l) associated with any single grab or composite sample.

b. Concentration Averages.

A concentration average, other than for fecal coliform bacteria, is the arithmetic mean of samples collected over the specified consecutive day period. The concentration average for fecal coliform bacteria is the geometric mean of the samples collected over the specified consecutive day period.

c. Discrete Sample.

An individual sample collected in less than 15 minutes.

d. Composite Sample.

A combination of no fewer than four individual samples obtained at equal time intervals over the specified sampling period. The volume of each individual sample shall be proportional to the discharge flow rate at the time of sampling. The sampling period shall be not less than one hour.

e. Monthly Average Removal Efficiency.

The montly average removal efficiency shall be the percentage of a pollutant which is removed from the influent waste stream into a treatment facility prior to discharge from the treatment facility. The percentage removal shall be calculated using the arithmetic average of the values calculated using the results of analyses of all samples collected during any 30 consecutive calendary day period. Influent and effluent samples used in the calculation of removal efficiency shall be collected as nearly simultaneously as is feasible.

f. Implementation Schedule (Schedule of Compliance)

Composed of two integral parts:

(1) plan - description of new or modified facilities to treat and dispose of the effluent;

(2) compliance schedule - a timetable setting forth the date by which all wastewaters will be in compliance with the effluent limitations of the permit. The schedule shall include (if appropriate) dates by which the permittee will accomplish:

1. Completion of a preliminary engineering plan report;
2. Completion of construction plans and specifications;
3. Initiation of construction;
4. Completion of construction;
5. Demonstration of compliance with effluent limitations.

g. Reapplication

If the permittee desires to continue to discharge, he shall reapply not later than 180 days before this permit expires, on the application forms then in use.

883

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